(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 299 289 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
19.02.2020 Bulletin 2020/08

(51) Int Cl.:
B64C 27/14 (2006.01) ***B64D 35/00*** (2006.01)
B64C 27/12 (2006.01) ***F16H 57/04*** (2010.01)

(21) Application number: **17192689.2**

(22) Date of filing: **22.09.2017**

(54) REDUNDANT COOLING SYSTEM

REDUNDANTES KÜHLSYSTEM

SYSTÈME DE REFROIDISSEMENT REDONDANT

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority:
23.09.2016 US 201662399097 P
17.11.2016 US 201662423371 P
20.09.2017 US 201715709511

(43) Date of publication of application:
28.03.2018 Bulletin 2018/13

(73) Proprietor: **Bell Helicopter Textron Inc.**
Fort Worth, TX 76101 (US)

(72) Inventors:
- **WEAVER, Keith David**
North Richland Hills, TX 76180 (US)
- **PUJOL, Michael**
Dallas, TX 75229 (US)
- **BIRKENHEUER, Andrew Jordan**
Arlington, TX 76011 (US)
- **PLAGIANOS, Nicholas**
N. Richland Hills, TX 76182 (US)
- **BURGE, Karl R.**
Hurst, TX 76054 (US)
- **POSTER, Scott David**
Arlington, TX 76016 (US)
- **MAST, Thomas**
Carrollton, TX 75007 (US)

(74) Representative: **Barker Brettell LLP**
100 Hagley Road
Edgbaston
Birmingham B16 8QQ (GB)

(56) References cited:
EP-A2- 1 669 551
EP-A2- 2 716 889
WO-A1-2016/018498
AU-A4- 2016 100 268
US-A- 4 999 994
US-A1- 2006 180 703
US-A1- 2014 312 722

EP 3 299 289 B1

Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates in general to the field of rotorcraft, and more particularly to methods and systems for cooling rotorcraft systems.

BACKGROUND OF THE INVENTION

[0002] Without limiting the scope of the invention, its background is described in connection with rotorcraft drive systems.

[0003] Since their inception, rotorcraft and rotorcraft drive systems have been improved to reduce the possibility of failure during flight. Toward that end, a number of modifications have been made to drive systems to improve reliability. However, despite advances in materials and design, a number of failures continue to occur that affect rotorcraft performance. One example of a problem with current rotorcraft drive systems is that, in some instances, the failure of single drive system component leads to failure of the entire drive system. Another example is a loss of lubrication event that causes the loss of torque transmission by drive system subcomponents such as gearboxes or accessories connected to the main rotor gearbox.

[0004] More particularly, the failure of a single gearbox or shaft connected to the main rotor gearbox can significantly impact operations. For example, if there is a loss of lubrication to a gearbox, the gearbox loses torque transmission causing damage to upstream or downstream components. The same can occur when a shaft becomes unbalanced (or breaks), which can damage couplings, gearboxes and even the main rotor gearbox. Unfortunately, when a portion of a drive system experiences a failure or reduction in performance, the concomitant reduction in power leads to challenges with flight performance.

[0005] Thus, a need remains for improving the overall safety and reliability of rotorcraft drive systems that include the connections between the engines and the main rotor gearbox, reduction and accessory gearboxes, shafts, generators, oil pumps, and accessories connected to the main rotor gearbox.

[0006] US 4,999,994 (A) discloses a turbo engine with a gas turbine to drive propellers or propfan blades which includes a speed reduction transmission interposed behind the gas turbine output drive shaft and the propellers or propfan blades. A cooling air impeller provides a supply of cooling air to an oil cooler for the speed reduction transmission. The impeller is arranged directly on the turbine output drive shaft.

[0007] US 2006/180,703 (A1) discloses a heat exchanger systems and associated systems and methods for cooling aircraft starters/generators. A heat exchanger system is discloses that includes a first fluid flow path for a first fluid, a second fluid flow path for a second fluid, and a third fluid flow path for a third fluid. The first and second flow paths are positioned proximate to the third flow path to transfer heat between the third fluid and both the first and second fluids. The third flow path is configured to allow a transfer of heat between the second and third fluids at a first transfer rate when the first fluid carries heat at a first rate, and at a second transfer rate different than the first transfer rate when the first fluid does not carry heat, or carries heat at a second rate less than the first rate.; Accordingly, when the heat to be rejected by one fluid is decreased, the heat transfer rate for the remaining fluid can be increased

[0008] AU 2016 100 268 discloses a multi-axis passenger-carrying aircraft comprising a heat exchange system, a cabin, and a passenger accommodating compartment arranged inside the cabin, wherein the electrical system is arranged inside the passenger accommodating compartment, and wherein the heat exchange system is at least communicated with an air inlet on the exterior of the cabin, an air outlet in communication with the passenger accommodating compartment, and a cooling and heating device with an air inlet end communicated with the air inlet and an air outlet end communicated with the air outlet. In operation, air outside the aircraft may enter the heat exchange system via the air inlet and the cooling and heating device via the air inlet end to be cooled or heated by the cooling and heating device as desired. The air after heat exchange may be discharged via the air outlet end and enter the passenger accommodating compartment via the air outlet, providing cool air or warm air to the passenger accommodating compartment, allowing more comfort for the passenger(s) in the passenger accommodating compartment.

[0009] Existing methods and apparatuses for cooling systems such as a main rotor gearbox and accessory gearboxes, and reduction gearboxes typically do not have a capacity for continued operation if components fail. If a fan fails, for example, existing methods and apparatuses typically have no ability to operate in the absence of the failed fan. Methods and apparatuses for providing redundancy for components of cooling systems in rotorcraft are desirable.

SUMMARY OF THE INVENTION

[0010] According to the present disclosure, there is provided an apparatus according to claim 1, a method according to claim 14, and a rotorcraft according to claim 27. Optional features of the apparatus, method, and rotorcraft are set out in the dependent claims.

[0011] In some embodiments of the disclosure, a cooling apparatus includes a shared cooling device for one or more systems or components, and a plurality of primary cooling pathways. Each of the primary cooling pathways includes a transition duct and a fan. The transition duct is in fluid communication with the shared cooling device. The fan is in fluid communication with the transition duct. In some embodiments, a shared connector in fluid communication with the shared cooling device, wherein the shared connector comprises a plurality of channels and each of the primary cooling pathways is operably configured to be in fluid communication with one of the channels. In some embodiments, a partition (fixed, articulated or actuated) is included within the shared connector, wherein the partition separates each of the channels of the plurality of channels from all of the other channels. The articulated or actuated partition can move to place substantially all of the shared cooling device in fluid communication with one primary cooling pathway of the plurality of primary cooling pathways. In some embodiments, the shared cooling device includes a plurality of cores, wherein each core is configured to cool one of the one or more systems or components, and wherein each core is oriented to the partition or the transition ducts such that each core is in fluid communication with at least one of the plurality of primary cooling pathways. In some embodiments, each of one or more of the primary cooling pathways further includes a transition connector that is in fluid communication with the transition duct of the primary cooling pathway and the fan of the primary cooling pathway. In some embodiments, the cooling apparatus further includes one or more secondary cooling pathways, wherein each of the one or more one secondary cooling pathway includes a conduit in fluid communication with the transition duct of one of the primary cooling pathways, and a distributed cooling device in fluid communication with the conduit. In some embodiments, the distributed cooling device and/or the shared cooling device is operably coupled to the one or more systems or components, such as a main rotor gearbox, an accessory gearbox, one or more components driven by the accessory gearbox, a reduction gearbox, a hydraulic system, a lubrication system, or a temperature control system. In some embodiments, each transition duct, conduit, shared connector, transition connector, or a combination thereof comprises at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

[0012] In some embodiments of the disclosure, a method of cooling one or more systems or components includes providing a shared cooling device for the one or more systems or components, and disposing each of a plurality of primary cooling pathways in fluid communication with the shared cooling device by: disposing a transition duct in fluid communication with the shared cooling device; and disposing a fan in fluid communication with the transition duct. In some embodiments, a shared connector is disposed in fluid communication with the shared cooling device, wherein the shared connector comprises a plurality of channels and each of the primary cooling pathways is operably configured to be in fluid communication with one of the channels. In some embodiments, a partition (fixed, articulated or actuated) is disposed within the shared connector, wherein the partition separates each of the channels of the plurality of channels from all of the other channels. The articulated or actuated partition can move to place substantially all of the shared cooling device in fluid communication with one primary cooling pathway of the plurality of primary cooling pathways. In some embodiments, the shared cooling device includes a plurality of cores, wherein each core is configured to cool one of the one or more systems or components, and further disposing each core in an orientation to the partition or the transition ducts such that each core is in fluid communication with at least one of the plurality of primary cooling pathways. In some embodiments, the method further includes disposing a transition connector for each of the one or more primary cooling pathways by disposing the transition connector in fluid communication with the transition duct of the primary cooling pathway and in fluid communication with the fan of the primary cooling pathway. In some embodiments, the method further includes disposing each of one or more secondary cooling pathways in fluid communication with one of the primary cooling pathways by: disposing a conduit in fluid communication with the transition duct of one of the primary cooling pathways; and disposing a distributed cooling device in fluid communication with the conduit. In some embodiments, the method further includes operably coupling the distributed cooling device and/or the shared cooling device to the one or more systems or components, such as a main rotor gearbox, an accessory gearbox, one or more components driven by the accessory gearbox, a reduction gearbox, a hydraulic system, a lubrication system, or a temperature control system. In some embodiments, each transition duct, conduit, shared connector, transition connector, or a combination thereof comprises at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

[0013] In some embodiments of the disclosure, a rotorcraft includes a fuselage, one or more engines coupled to the fuselage, a shared cooling device for one or more systems or components, and a plurality of primary cooling pathways. The shared cooling device is coupled to the one or more systems or components. Each of the primary cooling pathways includes a transition duct and a fan. The transition duct is in fluid communication with the shared cooling device. The fan is in fluid communication with the transition duct. In some embodiments, the rotorcraft includes some of the additional components and/or functionality described above in reference to the cooling apparatus and method.

[0014] In addition to the foregoing, various other method, system, and apparatus aspects are set forth in the teachings of the present disclosure, such as the claims, text, and drawings forming a part of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] For a more complete understanding of the features and advantages of the present invention, reference is now made to the detailed description of the invention along with the accompanying figures, in which:

FIG. 1 shows a side view of a helicopter according to a particular embodiment of the present application;

FIG. 2 shows a partial cross-section, perspective view of a helicopter according to an embodiment of the present application;

FIG. 3A shows a perspective view of a cooling system;

FIG. 3B illustrates a transmission system and the interior view of shared cooling device;

FIG. 4 shows a simplified diagram of a cooling apparatus;

FIG. 5 depicts a flowchart of a method of cooling one or more systems or components;

FIG. 6 depicts a flowchart of another method of cooling one or more systems or components;

FIG. 7 depicts a perspective view of a transition duct assembly;

FIG. 8 depicts a flowchart for a method of directing fluid flow in a cooling apparatus;

FIG. 9 depicts a flowchart for another method of directing fluid flow in a cooling apparatus;

FIG. 10 depicts a perspective view of a redundant fan set in conjunction with a cooling apparatus;

FIG. 11 depicts a perspective view of a fan assembly;

FIG. 12 depicts a flowchart of a method of cooling one or more systems or components;

FIG. 13 depicts a flowchart of another method of cooling one or more systems or components;

FIG. 14 depicts a fan blade assembly mounted on a shaft; and

FIG. 15 depicts a flowchart of a method of cooling one or more systems or components.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Illustrative embodiments of the system of the present application are described below. In the interest of clarity, not all features of an actual implementation are described in this specification.

[0017] In the specification, reference may be made to the spatial relationships between various components and to the spatial orientation of various aspects of components as the devices are depicted in the attached drawings. However, as will be recognized by those skilled in the art after a complete reading of the present application, the devices, members, apparatuses, etc. described herein may be positioned in any desired orientation. Thus, the use of terms such as "above," "below," "upper," "lower," or other like terms to describe a spatial relationship between various components or to describe the spatial orientation of aspects of such components should be understood to describe a relative relationship between the components or a spatial orientation of aspects of such components, respectively, as the device described herein may be oriented in any desired direction.

[0018] The present invention addresses the problems with drive systems in use today that are known to lead to rotorcraft failure. More particularly, the drive system of the present invention was designed to overcome drive system failures by including one or more of the following design features: (1) minimize the number of single path drive system components; (2) provide maximum system separation and redundancy; (3) minimize maintenance requirements and maintenance related incidents; (4) minimize the potential of loss of lubrication events; and/or (5) maximize main rotor gearbox loss of lubrication capability. The rotorcraft drive system described herein includes, e.g., dual engine reduction gearboxes completely isolated from the remainder of drive system via freewheeling clutches in the main rotor gearbox, dual accessory gearboxes separate from the main rotor gearbox, and the distribution of the gearbox driven accessories among the separate systems, among other improvements.

[0019] The present invention was developed to address the failures common to rotorcraft drive systems and is based on a completely new design and application of new technology to rotorcraft safety. More particularly, the new rotorcraft drive system is focused in an unparalleled manner on safety and redundancy. The goal of safety drove the design and development of the unique layout and configuration of the rotorcraft drive system described herein, which incorporates unique features and system separation that protects primary aircraft systems from the most common drive system failures. The drive system has also been designed to maximize the operational capability in the event of an uncommon failure, such as a loss of lubrication.

[0020] Moreover, the present inventors recognized that high-speed gearing and the associated heat generation is always an area of concern for gearbox survivability. The ability to continue torque transmission, particularly in a loss of lubrication scenario, is of great importance. For this reason, the drive system described herein includes two separate reduction gearboxes (RGB's), each one connected to a separate engine and independent from the Main Rotor Gearbox (MRGB). The reduction gearboxes are fully self-contained and separate from each other, each reducing the engine output speed from a high speed at or near turbine engine speed of greater than 10,000 RPM to a speed substantially lower than the high speed, a low speed of less than about 6,000 RPM, prior to transmitting torque to the MRGB. With this drive system arrangement high-speed gearing is contained in separate gearboxes, as such, the survivability of the total drive system is greatly enhanced, particularly in the event of high-speed gear failure or loss of lubricant in an individual RGB.

[0021] With this arrangement, where high-speed gearing is contained in separate gearboxes, the survivability of the total drive system is greatly enhanced, particularly in the event of high speed gear failure or loss of lubricant in an individual RGB. Each reduction gearbox can be disconnected from the MRGB by a clutch.

[0022] The Main Rotor Gearbox (MRGB) transmits torque from the Reduction Gearboxes (RGB) to the main rotor mast, to the accessory gearboxes, to the hydraulic pump and generator that is mounted to the MRGB, to the tail rotor drive shaft, and/or to the cooling fans.

[0023] The drive system and the associated cooling apparatus of the present invention can also take advantage of a number of additional features that minimize the possibility of loss of lubricant, to maximize the operational time if a loss of lubricant event does occur, and to maximize the operational time if a fan in the cooling apparatus fails. The cooling apparatus can include redundant fans, a transition duct between a shared cooler and the redundant fans that enable one fan to cool an engine or gearbox if a fans fails, and fan blade assemblies mounted on drive shafts or gearshafts without the need for high-speed grease-packed bearings. The drive system can also include one or more of the following: (1) the use of transfer tubes for cooler and filter mounting to eliminate the loss of lubricant in the event of loss of attachment fastener torque; (2) using an oil cooler mounted directly to the main rotor gearbox eliminating external hoses; (3) the use of all oil filter bowls are screw-on instead of held-on with small fasteners eliminating fastener failure issue from repeated removals; (4) the elimination of a high speed planetary and the heat generation associated with it during a loss of lubrication event; (5) the use of gear tooth geometry specifically designed to minimize sliding reducing heat generation at the teeth and the tendency to score during a loss of lubrication event; (6) the use of coarse pitch power gears with clearance or backlash allowing for the expansion during high heat loss of lubrication events; (7) the use of high hot hardness material utilized for primary torque carrying components maximizing their continued operation during a loss of lubrication event; (8) the use of ring gear and case joint design to efficiently transmit heat away from the planetary gears in the event of a loss of lubrication event; and/or (9) the use of isotropic super finished gear teeth resulting in a greatly improved surface finish and maximizing the ability of these gears to operate in a reduced lubrication environment.

[0024] FIG. 1 shows an aircraft 100 in accordance with a preferred embodiment of the present application. In the exemplary embodiment, aircraft 100 is a helicopter having a fuselage 102 and a rotor system 104 carried thereon. A plurality of rotor blades 106 is operably associated with a rotor system 104 for creating flight. A tail boom 108 is depicted that further includes tail rotor 110.

[0025] For example, FIG. 2 shows a partial cross-section perspective view of aircraft 100 that includes additional detail of the present invention. Aircraft 100 further includes a rotor mast 112, which is connected to the main rotor gearbox 114 via a main rotor mast. The main rotor gearbox 114 is connected to one or more accessory gear boxes 116 and one or more reduction gearboxes 216a, 216b. Each reduction gearbox 216a, 216b is connected to one or more engines 120a, 120b, which are within an engine compartment 118. A tail rotor drive shaft 122 transmits mechanical rotation to the tail rotor gear box 124, which is connected via tail rotor drive shaft 126 and intermediate gear box 128.

[0026] FIG. 3A shows a perspective view of an embodiment of the present invention, cooling apparatus 300. Cooling apparatus 300 includes a shared cooling device 305 through which air is drawn to cool a coolant such as oil. In FIG. 3A, shared cooling device 305 is illustrated as operably coupled with main rotor gearbox 114 to cool oil circulated through main rotor gearbox 114, but the skilled artisan will recognize that cooling apparatus 300 may be used to cool other components with oil or other coolants. Shared cooling device 305 is exemplary; other types of cooling mechanisms such as one or more coolers or heat exchangers may be used for the same purpose. Shared cooling device 305 is in fluid communication through shared connector 310 with first transition duct 320 and second transition duct 325.

[0027] In some embodiments, the first and second transition ducts 320 and 325 partially extend into the shared connector 310 to provide system redundancy in the event of a failed blower. Note that complete separation of the flow paths is not required so long as there is adequate path separation to provide the required system redundancy. In other embodiments, shared connector 310 includes partition 315 (not shown) that forms two channels within shared connector 310. One of the channels is in fluid communication with first transition duct 320 and the other channel is in fluid communication with second transition duct 325. Shared connector 310 is illustrated here as articulated or actuated to permit relative movement between shared cooling device 305 and the first transition duct 320 and second transition duct 325. First transition duct 320 is in fluid communication with first transition connector 330 and second transition duct 325 is in fluid communication with second transition connector 335.

[0028] First transition connector 330 is in fluid communication with first fan 340, which expels air through first exhaust port 341, and second transition connector 335 is in fluid communication with second fan 345, which expels air through second exhaust port 346. First fan 340 or second fan 345 may be a centrifugal fan, an axial-flow fan, a cross-flow fan, or another type of fan as convenient in various circumstances. First fan 340 and second fan 345 are operably independent of each other, including being electrically powered independently or mechanically driven independently of each other. First transition connector 330 and second transition connector 335 are illustrated here as articulated or actuated to permit relative movement between first fan 340 and first transition duct 320 on the one hand and, on the other hand, between second fan 345 and second transition duct 325. The skilled artisan will recognize that items in fluid communication may be in direct fluid communication, with the items in physical proximity, or in indirect fluid communication, with the items that are in fluid communication separated by other items. A transition duct, such as first transition duct 320 and second transition duct 325, a transition connector, such as first transition connector 330 and second transition connector 335, or a shared connector, such as shared connector 310, may include at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

[0029] Continuing reference to FIG. 3A, first conduit 350 is in fluid communication with first transition duct 320 and second conduit 355 is in fluid communication with second transition duct 325. First distributed cooling device 360 (e.g., heat exchanger) is in fluid communication with first conduit 350, and second distributed cooling device 365 (e.g., heat exchanger) is in fluid communication with second conduit 355. First distributed cooling device 360 is a cooling system powered by first accessory gearbox 116a to cool a second hydraulic power pack 370 (FIGS. 10-11). Second distributed cooling device 365 is a cooling system powered by second accessory gearbox 116b to cool a third hydraulic power pack 375 (FIGS. 10-11). Air is drawn through first distributed cooling device 360 to cool oil circulated through first distributed cooling device 360 by a hydraulic pump in second hydraulic power pack 370 that is driven by the first accessory gearbox 116a. Likewise, air is drawn through second distributed cooling device 365 to cool oil circulated through second distributed cooling device 365 by a hydraulic pump in third hydraulic power pack 375 that is driven by the second accessory gearbox 116b. First distributed cooling device 360 and second distributed cooling device 365 are exemplary; other types of cooling mechanisms such as one or more coolers or heat exchangers may be used for the same purpose. A conduit, such as first conduit 350 and second conduit 355, may include at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

[0030] First fan 340, first transition connector 330, and first transition duct 320 are included in a first primary cooling pathway and second fan 345, second transition connector 335, and second transition duct 325 are included in a second primary cooling pathway. First fan 340 draws air through the first primary cooling pathway from shared cooling device 305, which cools oil circulated through shared cooling device 305 from main rotor gearbox 114 and expels the heated air through first exhaust port 341. Second fan 345 draws air through the second primary cooling pathway from shared cooling device 305, which cools oil circulated through shared cooling device 305 from main rotor gearbox 114 and expels the heated air through second exhaust port 346. Cooling apparatus 300 is illustrated as having two primary cooling pathways from shared cooling device 305, but the skilled artisan will recognize that cooling apparatus 300 may have two or more such primary cooling pathways. The skilled artisan will also recognize that where there are more than two primary cooling pathways, shared connector 310 will have more than two channels, each of which is in fluid communication with a distinct transition duct. The skilled artisan will further recognize that where there are more than two primary cooling pathways, each cooling pathway includes a fan, and all of the fans are operably independent of each other, including being electrically powered independently or mechanically driven independently of each other. A transition connector, such as first transition connector 330 and second transition connector 335, may include at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof. The skilled artisan will recognize that a cooling pathway, such as the first and second primary cooling pathways herein, may have more or fewer items than those illustrated or discussed herein.

[0031] First conduit 350 and first distributed cooling device 360 are included in a secondary cooling pathway and second conduit 355 and second distributed cooling device 365 are included in a secondary cooling pathway. First distributed cooling device 360 cools oil from second hydraulic power pack 370 that is circulated by a hydraulic pump in second hydraulic power pack 370 driven by the first accessory gearbox 116a. Likewise, second distributed cooling device 365 cools oil from third hydraulic power pack 375 that is circulated by a hydraulic pump in third hydraulic power pack 375 driven by the second accessory gearbox 116b. First fan 340 draws air from first distributed cooling device 360 through first conduit 350 and first transition duct 320, and it expels the air through first exhaust port 341. Second fan 345 draws air from second distributed cooling device 365 through second conduit 355 and second transition duct 325, and it expels the air through second exhaust port 346.

[0032] In an embodiment of cooling apparatus 300 with more than two primary cooling pathways, there is a single shared cooling device 305, a single shared connector 310, and three or more primary cooling pathways, each with a transition duct corresponding to first transition duct 320 and second transition duct 325, a transition connector corresponding to first transition connector 330 and second transition connector 335, and a fan corresponding to first fan 340 and second fan 345. In an aspect of cooling apparatus 300, there may be a secondary cooling pathway including a conduit corresponding to first conduit 350 and second conduit 355 and a distributed cooling device corresponding to first distributed cooling device 360 and second distributed cooling device 365. The skilled artisan will recognize that a cooling pathway, such as the first and second secondary cooling pathways herein, may have more or fewer items than those illustrated or discussed herein.

[0033] FIG. 3B illustrates a transmission system and an interior view of shared cooling device 305, which includes one or more exemplary cores, e.g., main rotor gearbox core 306, left-hand reduction gearbox core 307, right-hand gearbox core 308, and hydraulic systems core 309. Each of these cores in this multicore shared cooling device 305 is in fluid communication with shared connector 310 (not shown), and each of the cores is oriented to partition 315 such that airflow through cooling apparatus 300 can be maintained for cooling all of the systems or components served by these cores - main rotor gearbox 114, reduction gearboxes, one or more hydraulic systems, one or more lubrication systems, or one or more thermal control systems (such as other cooling systems or heating systems) - when both first fan 340 and second fan 345 are functioning and when only one fan, either first fan 340 or second fan 345, is operating, e.g., in the event of a fan failure. With the cores oriented perpendicular or orthogonal to the partition 315, air drawn through either the first primary cooling pathway or the second primary cooling pathway, in the event of a fan failure, or both cooling pathways in normal operations, flows through all of the cores, main rotor gearbox core 306, left-hand reduction gearbox core 307, right-hand gearbox core 308, and hydraulic systems core 309. Although the orientation of the cores is shown to be generally perpendicular or orthogonal to the partition 315, the skilled artisan will recognize that the cores and inlets to the cores may be made in other shapes and orientations such that the airflow across the cores can be other than perpendicular, e.g., at a 15, 20, 30, 45, 60, 80, or 85 degree angle while still providing airflow across the cores. Each core of the one or more cores included in shared cooling device 305 can be oversized to have sufficient cooling capacity to cool all of the systems or components coupled to it to maximize operational time in the event of a fan failure. As previously discussed, partition 315 is not required if the transition ducts partially extend into the shared connector 310 to provide sufficient separation such that system redundancy is provided in the event of a failed blower. Note that complete separation of the flow paths is not required as long as there is adequate path separation to provide the required system redundancy. In this case, the cores can be generally oriented to the transition ducts extending into the shared connector 310. When partition 315 is used, it can be fixed, articulated or actuated. To provide improved redundancy, partition 315 can be articulated or actuated to increase airflow across a greater area of shared cooling device 305 by moving to one side on shared connector 310, allowing air drawn through the primary cooling path of the operating fan to draw air over most or all of each of the cores, e.g., main rotor gearbox core 306, left-hand reduction gearbox core 307, right-hand gearbox core 308, and hydraulic systems core 309. Hydraulic systems core 309 cools a first hydraulic power pack (not shown).

[0034] FIG. 4 depicts a simplified diagram of cooling apparatus 300. FIG. 4 shows main rotor gearbox 114, shared cooling device 305, shared connector 310, partition 315 (optional), first channel 316, second channel 317, first transition duct 320, second transition duct 325, first transition connector 330, second transition connector 335, first fan 340, first exhaust port 341, second fan 345, second exhaust port 346, first conduit 350, second conduit 355, first distributed cooling device 360, second distributed cooling device 365, first accessory gearbox 116a, and second accessory gearbox 116b. Arrows depict airflows through the primary and secondary cooling pathways from the shared cooling device 305 and from the first distributed cooling device 360 and second distributed cooling device 365 through first fan 340 and second fan 345 and out through first exhaust port 341 and second exhaust port 346. In some embodiments, partition 315 is eliminated and the partition functionality is provided by the length in which the ducts 320 and 325 extend forward into connector 310. In some other embodiments, partition 315 is fixed in place. In yet some other embodiments, partition 315 can be articulated or actuated to move to one side or the other of shared connector 310 in the event of a fan failure, allowing air drawn through the primary cooling path of the operating fan to draw air over most or all of each of the cores included in shared cooling device 305. In FIG 4, partition 315 is depicted as a solid line in the position in which air is drawn through both the first and second primary cooling pathways and as dotted lines in the positions in which partition 315 is moved to one side or the other of shared connector 310.

[0035] Here, cooling apparatus 300 is shown operably coupled with main rotor gearbox 114, first accessory gearbox 116a and second accessory gearbox 116b to power shared cooling device 305, first distributed cooling device 360 and second distributed cooling device 365, respectively. The skilled artisan will recognize that cooling apparatus 300 may be operably coupled to cool other systems or components than those specifically described herein, such as the first accessory gearbox 116a, second accessory gearbox 116b, first reduction gearbox 216a, second reduction gearbox 216b, other hydraulic systems, one or more lubrication systems, or one or more thermal control systems. The skilled artisan will also recognize that cooling apparatus 300 may be used with other cooling mechanisms besides coolers such as shared cooling device 305, first distributed cooling device 360, and second distributed cooling device 365.

[0036] FIG. 5 depicts a flowchart of a method 500 of cooling one or more systems or components, illustrating an embodiment of the present invention. Method 500 includes block 505, providing a shared cooling device 305 for cooling one or more systems or components, such as the main rotor gearbox 114, the accessory gearboxes 116a, 116b, one or more components driven by the accessory gearboxes 116a, 116b, reduction gearboxes 216a, 216b, one or more hydraulic systems (e.g., first hydraulic power pack), one or more lubrication systems, or one or more thermal control systems, and further includes block 510, disposing each of a plurality of primary cooling pathways in fluid communication with the shared cooling device 305 by disposing a transition duct, such as first transition duct 320 or second transition duct 325, in fluid communication with the shared cooling device 305 and disposing a fan, such as first fan 340 or second fan 345, in fluid communication with the transition duct.

[0037] FIG. 6 depicts a flowchart of a method 600 of cooling a component, illustrating another embodiment of the present invention. Method 600 includes block 605, providing a shared cooling device 305 for cooling one or more systems or components, such as the main rotor gearbox 114, the accessory gearboxes 116a, 116b, one or more components driven by the accessory gearboxes 116a, 116b, the reduction gearboxes 216a, 216b, one or more hydraulic systems (e.g., first hydraulic power pack), one or more lubrication systems, or one or more thermal control systems. Method 600 further includes block 610, disposing a first transition duct 320 in fluid communication with the shared cooling device 305. Method 600 further includes block 615, disposing a first fan 340 in fluid communication with the first transition duct 320. Method 600 further includes block 620 disposing a first conduit 350 in fluid communication with the first transition duct 320. Method 600 further includes block 625, disposing a first distributed cooling device 360 in fluid communication with the first conduit 350. Method 600 further includes block 630, disposing a second transition duct 325 in fluid communication with the shared cooling device 305. Method 600 further includes block 635, disposing a second fan 345 in fluid communication with the second transition duct 325. Method 600 further includes block 640, disposing a second conduit 355 in fluid communication with the second transition duct 325. Method 600 further includes block 645, disposing a second distributed cooling device 365 in fluid communication with the second conduit 355.

[0038] The skilled artisan will recognize that cooling apparatus 300 and methods 500 and 600 of cooling a system or component provide safety-enhancing redundant cooling for aircraft systems or components by providing more than one cooling pathway for the system or component to be cooled, permitting continued operations if a cooling pathway becomes inoperative.

[0039] FIG. 7 shows a perspective view of an embodiment of the present invention, transition duct assembly 700. Transition duct assembly 700 includes a shared connector 310. Within shared connector 310, partition 315 (optional) forms first channel 316 and second channel 317 within shared connector 310. Transition duct assembly 700 is exemplary of any type of mechanical connection or connections that places ducts and fans in fluid communication. In some embodiments, partition 315 is eliminated and the partition functionality is provided by the lengths by which the ducts 320 and 325 extend forward into connector 315. In some other embodiments, partition 315 is fixed in place. In yet some other embodiments, partition 315 can be articulated or actuated to increase airflow across a greater area of shared cooling device 305. In an embodiment in which transition duct assembly 700 is part of cooling apparatus 300, in normal operations with both first fan 340 and second fan 345 operating, first channel 316 is in fluid communication with first transition duct 320, and second channel 317 is in fluid communication with second transition duct 325. First transition connector 330 is in fluid communication with first transition duct 320 and second transition connector 335 is in fluid communication with second transition duct 325. First conduit 350 is in fluid communication with first transition duct 320 and second conduit 355 is in fluid communication with second transition duct 325. When partition 315 is moved to one side or the other of shared connector 310, one of first channel 316 or second channel 317 is closed off and the remaining open channel is usable through which to draw air through either first transition duct 320 or second transition duct 325 to cool the systems or components cooled by shared cooling device 305.

[0040] FIG. 8 depicts a flowchart of a method 800 for directing fluid flow in a cooling apparatus such as cooling apparatus 300, illustrating an embodiment of the present invention. Method 800 includes block 805, providing a shared connector 310; optional block 810, forming a one or more channels, e.g. first channel 316 and second channel 317, within the shared connector 310; and block 815, providing each of a plurality of primary cooling pathways for cooling one or more systems or components, such as the main rotor gearbox 114, the accessory gearboxes 116a, 116b, one or more components driven by the accessory gearboxes 116a, 116b, the reduction gearboxes 216a, 216b, one or more hydraulic systems, one or more lubrication systems, or one or more thermal control systems, wherein each of the primary cooling pathways is in fluid communication with the shared connector 310 by disposing a transition duct, e.g., first transition duct 320 or second transition duct 325, operably configured to be placed in fluid communication with one of the plurality of channels, e.g., first channel 316 or second channel 317 (or the shared connector 310); and disposing a transition connector, e.g., first transition connector 330 or second transition connector 335, in fluid communication with the transition duct, e.g., first transition duct 320 or second transition duct 325.

[0041] FIG. 9 depicts a flowchart of a method 900 for directing fluid flow in a cooling apparatus such as cooling apparatus 300, illustrating an embodiment of the present invention. Method 900 includes block 905, providing a shared connector 310; block 910, forming two channels, first channel 316 and second channel 317, within the shared connector; block 915, disposing a first primary cooling pathway for cooling one or more systems or components, such as the main rotor gearbox 114, the accessory gearboxes 116a, 116b, one or more components driven by the accessory gearboxes 116a, 116b, the reduction gearboxes 216a, 216b, one or more hydraulic systems, one or more lubrication systems, or one or more thermal control systems, wherein the first primary cooling pathway is in fluid communication with the shared connector 310, further including disposing a first transition duct 320 in fluid communication with a first channel 316 of the two channels, first channel 316 and second channel 317, and disposing a first transition connector 330 in fluid communication with the first transition duct 320; and block 920, disposing a second primary cooling pathway for cooling one or more systems or components, such as the main rotor gearbox 114, the accessory gearboxes 116a, 116b, one or more components driven by the accessory gearboxes 116a, 116b, the reduction gearboxes 216a, 216b, or one or more hydraulic systems, one or more lubrication systems, or one or more thermal control systems, wherein the second primary cooling pathway is in fluid communication with the shared connector 310, further including disposing a second transition duct 325 in fluid communication with a second channel 317 of the two channels, first channel 316 and second channel 317, and disposing a second transition connector 335 in fluid communication with the second transition duct 325.

[0042] The skilled artisan will recognize that transition duct assembly 700 and methods 800 and 900 of cooling one or more systems or components provide safety-enhancing redundant cooling for aircraft systems or components by providing more than one cooling pathway for the system or component to be cooled, permitting continued operations if a cooling pathway becomes inoperative.

[0043] FIG. 10 shows a perspective view of an embodiment of the present invention, redundant fan set 1000, in conjunction with cooling apparatus 300. Redundant fan set 1000 includes two fan assemblies, the first fan assembly 1005 including first fan 340 and first exhaust port 341, and the second fan assembly 1010 including second fan 345 and second exhaust port 346. First fan 340 expels air through first exhaust port 341, and second fan 345 expels air through second exhaust port 346. First fan 340 and second fan 345 are operably independent of each other, including being electrically powered independently or mechanically driven independently of each other. If either fan fails, the other fan will continue to operate despite the failure. First fan 340 and second fan 345 each independently have the capacity to move air through a cooling apparatus such that the systems or components to be cooled can be cooled by either first fan 340 operating by itself or second fan 345 operating by itself. FIG. 10 also shows main rotor gearbox 114, first accessory gearbox 116a, second accessory gearbox 116b, second hydraulic power pack 370, third hydraulic power pack 375 of aircraft 100 as examples of components that require cooling.

[0044] FIG. 11 depicts a perspective view of first fan assembly 1005, including first fan 340, first exhaust port 341, and first fan blade assembly 1105. FIG. 11 also depicts first distributed cooling device 360, first accessory gearbox 116a and second hydraulic power pack 370.

[0045] FIG. 12 depicts a flowchart of a method 1200 of cooling one or more systems or components, illustrating an embodiment of the present invention. Method 1200 includes block 1205, providing a shared cooling device 305 for cooling one or more systems or components, such as the main rotor gearbox 114, accessory gearboxes 116a, 116b, one or more components driven by the accessory gearboxes 116a, 116b, reduction gearboxes 216a, 216b, or one or more hydraulic systems, one or more lubrication systems, or one or more thermal control systems, and also includes block 1210, disposing a plurality of primary cooling pathways by disposing a fan for each of the primary cooling pathways, wherein the fan, e.g., first fan 340 or second fan 345, is in fluid communication with the shared cooling device 305.

[0046] FIG. 13 depicts a flowchart of a method 1300 of cooling one or more systems or components, illustrating another embodiment of the present invention. Method 1300 includes block 1305, providing a shared cooling device 305 for cooling one or more systems or components, such as the main rotor gearbox 114, accessory gearboxes 116a, 116b, one or more components driven by the accessory gearboxes 116a, 116b, reduction gearboxes 216a, 216b, or one or more hydraulic systems, one or more lubrication systems, or one or more thermal control systems. Method 1300 further includes block 1310, disposing a first fan 340 in fluid communication with the shared cooling device. Method 1300 also includes block 1315, disposing a second fan 345 in fluid communication with the shared cooling device, wherein the first fan 340 and the second fan 345 are electrically powered independently or mechanically driven independently of each other.

[0047] The skilled artisan will recognize that redundant fan set 1000 and methods 1200 and 1300 provide safety-enhancing redundant cooling for aircraft systems or components by providing more than one fan for the system or component to be cooled, permitting continued operations if a fan becomes inoperative.

[0048] FIG. 14 depicts an embodiment of the present invention, a fan blade assembly mounted on a shaft. The skilled artisan will recognize that a shaft on which a fan blade assembly is mounted may be a drive shaft or a gearshaft. Shown here is first fan blade assembly 1105 of first fan 340 mounted on first gearshaft 1115. First gearshaft 1115 protrudes from and is operably coupled to first accessory gearbox 116a to be turned by first accessory gearbox 116a. First accessory gearbox 116a is a device for transmitting energy by rotating first gearshaft 1115. When first accessory gearbox 116a turns the first gearshaft 1115, first fan blade assembly 1105 turns with first gearshaft 1115. Thus, the operation of first accessory gearbox 116a turns first fan blade assembly 1105 of first fan 340, which draws air through first distributed cooling device 360, first conduit 350, first transition duct 320, and first transition connector 330 (not shown here; see FIGS. 3A and 4), to cool the second hydraulic power pack 370 and components driven by the first accessory gearbox 116a. Not shown here is a similar arrangement for second fan 345, in which second fan assembly of second fan 345 is mounted on a second gearshaft that protrudes from and is operably coupled to second accessory gearbox 116b to be turned by second accessory gearbox 116b, so that when second accessory gearbox 116b turns the second gearshaft, second fan 345 draws air to cool the third hydraulic power pack 375 and components driven by the second accessory gearbox 116b. Using a gearshaft in this manner drives each fan independently because each fan blade assembly is a on a separate gearshaft of a separate accessory gearbox. If one accessory gearbox fails and the associated fan blade assembly stops turning, another accessory gearbox, absent an independent failure, will continue to operate and will continue to draw air to cool the system or component being cooled by the cooling apparatus 300. The skilled artisan will recognize that a fan blade assembly may include an impeller, a rotor, or another assembly of blades associated with a fan or a blower generally.

[0049] FIG. 15 depicts a flowchart of a method 1500, a method for cooling a one or more systems or components, illustrating another embodiment of the present invention. Method 1500 includes block 1505, providing one or more fans, e.g., first fan 340 or second fan 345, wherein each of the one or more fans includes a fan blade assembly, e.g. first fan blade assembly 1105. Method 1500 further includes block 1510, operably coupling each of one or more shafts, e.g., first gearshaft 1115, to an engine or a gearbox, such as the engines 120a, 120b, the accessory gearboxes 116a, 116b, or the reduction gearboxes 216a, 216b, and wherein each fan blade assembly, e.g. first fan blade assembly 1105, of the one or more fans, e.g., first fan 340 or second fan 345, is disposed on one of the shafts e.g., first gearshaft 1115. The skilled artisan will recognize that each of a plurality of fan blade assemblies can be mounted on a shaft such as a gearshaft to provide as many shaft-mounted fan blade assemblies as may be needed for a given application.

[0050] The skilled artisan will recognize that method 1500 and mounting a fan blade assembly, such as first fan blade assembly 1105, directly on a gearshaft, such as first gearshaft 1115, eliminate the need for bearings to support the first fan blade assembly 1105, further eliminating the need for maintenance and replacement of bearings and enhancing safety.

Claims

1. A cooling apparatus (300), comprising:

a shared cooling device (305) for one or more systems or components;
a plurality of primary cooling pathways, wherein each of the primary cooling pathways comprises:

a transition duct (320, 325), wherein the transition duct (320, 325) is in fluid communication with the shared cooling device (305); and
a fan (340, 345), wherein the fan (340, 345) is in fluid communication with the transition duct (320, 325); and **characterized by**

a shared connector (310) in fluid communication with the shared cooling device (305);
wherein the shared connector (310) comprises a plurality of channels (316, 317); and
wherein each of the primary cooling pathways is operably configured to be in fluid communication with one of the channels (316, 317).

2. The apparatus (300) of claim 1, further comprising a partition (315) within the shared connector (310), wherein the partition (315) separates each of the channels (316, 317) of the plurality of channels (316, 317) from all of the other channels (316, 317).

3. The apparatus (300) of claim 2, wherein the partition (315) is articulated or actuated to move to place substantially all of the shared cooling device (305) in fluid communication with one primary cooling pathway of the plurality of primary cooling pathways.

4. The apparatus (300) of claim 2 or of claim 3, wherein the shared cooling device (305) comprises a plurality of cores, wherein each core is configured to cool one of the one or more systems or components, and wherein each core is oriented to the partition (315) or the transition ducts (320, 325) such that each core is in fluid communication with at least one of the plurality of primary cooling pathways.

5. The apparatus (300) of claim 1 or of any of claims 2 to 4, wherein the shared connector (310) comprises at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

6. The apparatus (300) of claim 1 or of any preceding apparatus claim, wherein each of one or more of the primary cooling pathways further comprises a transition connector (330, 335), wherein:

the transition connector (330, 335) is in fluid communication with the transition duct (320, 325) of the primary cooling pathway; and
the transition connector (330, 335) is in fluid communication with the fan (340, 345) of the primary cooling pathway.

7. The apparatus (300) of claim 6, wherein the transition connector (330, 335) comprises at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

8. The apparatus (300) of claim 1 or of any preceding apparatus claim, wherein each of the transition ducts (320, 325) comprises at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

9. The apparatus (300) of claim 1 or of any preceding apparatus claim, further comprising one or more secondary cooling pathways, wherein each of the one or more one secondary cooling pathway comprises:

a conduit (350, 355), wherein the conduit (350, 355) is in fluid communication with the transition duct (320, 325) of one of the primary cooling pathways; and
a distributed cooling device (360, 365), wherein the distributed cooling device (360, 365) is in fluid communication with the conduit (350, 355).

10. The apparatus (300) of claim 9, wherein each conduit (350, 355) comprises at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

11. The apparatus (300) of claim 9 or of claim 10, wherein the distributed cooling device (360, 365) is operably coupled to the one or more systems or components.

12. The apparatus (300) of claim 1 or of any preceding apparatus claim, wherein the one or more systems or components comprise a main rotor gearbox (114), an accessory gearbox (116a, 116b), one or more components driven by the accessory gearbox (116a, 116b), a reduction gearbox (216a, 216b), a hydraulic system, a lubrication system, or a temperature control system.

13. The apparatus (300) of claim 1 or of any preceding apparatus claim, wherein the shared cooling device (305) is operably coupled to the one or more systems or components.

14. A method of cooling one or more systems or components, comprising:

providing a shared cooling device (305) for the one or more systems or components; and
disposing each of a plurality of primary cooling pathways in fluid communication with the shared cooling device (305) by:

disposing a transition duct (320, 325) in fluid communication with the shared cooling device (305);
disposing a fan (340, 345) in fluid communication with the transition duct (320, 325); and **characterized by**
disposing a shared connector (310) in fluid communication with the shared cooling device (305), wherein the shared connector (310) comprises a plurality of channels (316, 317); and
disposing for each of the primary cooling pathways the transition duct (320, 325) to be operably configurable to be in fluid communication with one of the channels (316, 317).

15. The method of claim 14, further comprising disposing a partition (315) within the shared connector (310), wherein the partition (315) separates each of the channels (316, 317) of the plurality of channels (316, 317) from all of the other channels (316, 317).

16. The method of claim 15, wherein the partition (315) is articulated or actuated to move to place substantially all of the shared cooling device (305) in fluid communication with one primary cooling pathway of the plurality of primary cooling pathways.

17. The method of claim 15 or of claim 16, wherein the shared cooling device (305) comprises a plurality of cores, wherein each core is configured to cool one of the one or more systems or components, and further comprising disposing each core in an orientation to the partition (315) or transition ducts (320, 325) such that each core is in fluid communication with at least one of the plurality of primary cooling pathways.

18. The method of claim 14 or of any of claims 15 to 17, wherein the shared connector (310) comprises at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

19. The method of claim 14 or of any preceding method claim, further comprising disposing a transition connector (330, 335) for the each of one or more primary cooling pathways by:

disposing the transition connector (330, 335) in fluid communication with the transition duct (320, 325) of the primary cooling pathway; and disposing the transition connector (330, 335) in fluid communication with the fan (340, 345) of the primary cooling pathway.

20. The method of claim 19, wherein the transition connector (330, 335) comprises at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

21. The method of claim 14 or of any preceding method claim, wherein each of the transition ducts (320, 325) comprises at least a portion that is a rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

22. The method of claim 14 or of any preceding method claim, further comprising disposing each of one or more secondary cooling pathways in fluid communication with one of the primary cooling pathways by:

disposing a conduit (350, 355) in fluid communication with the transition duct (320, 325) of the one of the primary cooling pathways; and
disposing a distributed cooling device (360, 365) in fluid communication with the conduit (350, 355).

23. The method of claim 22, wherein the conduit (350, 355) comprises at least a portion that is rigid material, a flexible material, an articulated portion, a flexible portion, or a combination thereof.

24. The method of claim 22 or of claim 23, further comprising operably coupling the distributed cooling device (360, 365) of the each of the one or more secondary cooling pathways with one or more systems or components.

25. The method of claim 14 or of any preceding method claim, wherein the one or more systems or components comprise a main rotor gearbox (114), an accessory gearbox (116a, 116b), one or more components driven by the accessory gearbox (116a, 116b), a reduction gearbox (216a, 216b), a hydraulic system, a lubrication system, or a temperature control system.

26. The method of claim 14 or of any preceding method claim, further comprising operably coupling the shared cooling device (305) with the one or more systems or components.

27. A rotorcraft (100), comprising:

a fuselage (102);
one or more engines (120a, 120b) coupled to the fuselage (102);
a shared cooling device for one or more systems or components, wherein the shared cooling device (305) is coupled to the one or more systems or components;
a plurality of primary cooling pathways, wherein each of the primary cooling pathways comprises:

a transition duct, wherein the transition duct is in fluid communication with the shared cooling device; and
a fan, wherein the fan is in fluid communication with the transition duct; and **characterized by**

a shared connector (310) in fluid communication with the shared cooling device (305);
wherein the shared connector (310) comprises a plurality of channels (316, 317); and
wherein each of the primary cooling pathways is operably configured to be in fluid communication with one of the channels (316, 317).

Patentansprüche

1. Kühleinrichtung (300) umfassend:

eine geteilte Kühlvorrichtung (305) für ein(e) oder mehrere Systeme oder Komponenten;
eine Vielzahl von primären Kühlleitbahnen, wobei jede der primären Kühlleitbahnen umfasst:

einen Überleitschacht (320, 325), wobei der Überleitschacht (320, 325) in Fluidverbindung mit der geteilten Kühlvorrichtung (305) ist; und
einen Lüfter (340, 345), wobei der Lüfter (340, 345) in Fluidverbindung mit dem Überleitschacht (320, 325) ist; und **gekennzeichnet durch**
einen geteilten Verbinder (310) in Fluidverbindung mit der geteilten Kühlvorrichtung (305);
wobei der geteilte Verbinder (310) eine Vielzahl von Kanälen (316, 317) umfasst; und
wobei jede der primären Kühlleitbahnen betriebsfähig konfiguriert ist, in Fluidverbindung mit einem der Kanäle (316, 317) zu stehen.

2. Einrichtung (300) nach Anspruch 1, weiter umfassend einen Trennsteg (315) innerhalb des geteilten Verbinders (310), wobei der Trennsteg (315) jeden der Kanäle (316, 317) der Vielzahl von Kanälen (316, 317) von allen der anderen Kanäle (316, 317) trennt.

3. Einrichtung (300) nach Anspruch 2, wobei der Trennsteg (315) gelenkig oder angetrieben ist um sich zu bewegen, um im Wesentlichen die gesamte geteilte Kühlvorrichtung (305) in Fluidverbindung mit einer primären Kühlleitbahn der Vielzahl von primären Kühlleitbahnen zu platzieren.

4. Einrichtung (300) nach Anspruch 2 oder nach Anspruch 3, wobei die geteilte Kühlvorrichtung (305) eine Vielzahl von Kernen umfasst, wobei jeder Kern konfiguriert ist, eine(s) der einen oder mehr Systeme oder Komponenten zu kühlen und wobei jeder Kern zum Trennsteg (315) oder den Überleitschachten (320, 325) ausgerichtet ist, sodass jeder Kern in Fluidverbindung mit mindestens einer der Vielzahl von primären Kühlleitbahnen ist.

5. Einrichtung (300) nach Anspruch 1 oder einem der Ansprüche 2 bis 4, wobei der geteilte Verbinder (310) mindestens einen Abschnitt umfasst, der ein starres Material, ein flexibles Material, ein gelenkiger Abschnitt, ein flexibler Abschnitt oder eine Kombination davon ist.

6. Einrichtung (300) nach Anspruch 1 oder einem vorstehenden Einrichtungsanspruch, wobei jede von einer oder mehr der primären Kühlleitbahnen weiter einen Überleitverbinder (330, 335) umfasst, wobei:

der Überleitverbinder (330, 335) in Fluidverbindung mit dem Überleitschacht (320, 325) der primären Kühlleitbahn ist; und
der Überleitverbinder (330, 335) in Fluidverbindung mit dem Lüfter (340, 345) der primären Kühlleitbahn ist.

7. Einrichtung (300) nach Anspruch 6, wobei der Überleitverbinder (330, 335) mindestens einen Abschnitt umfasst, der ein starres Material, ein flexibles Material, ein gelenkiger Abschnitt, ein flexibler Abschnitt oder eine Kombination davon ist.

8. Einrichtung (300) nach Anspruch 1 oder einem vorstehenden Einrichtungsanspruch, wobei jede der Überleitschachte (320, 325) mindestens einen Abschnitt umfasst, der ein starres Material, ein flexibles Material, ein gelenkiger Abschnitt, ein flexibler Abschnitt oder eine Kombination davon ist.

9. Einrichtung (300) nach Anspruch 1 oder einem vorstehenden Einrichtungsanspruch, weiter umfassend eine oder mehr sekundäre Kühlleitbahnen, wobei jede der einen oder der mehr sekundären Kühlleitbahnen umfasst:

einen Leitkanal (350, 355), wobei der Leitkanal (350, 355) in Fluidverbindung mit dem Überleitschacht (320, 325) von einer der primären Kühlleitbahnen ist; und
eine verteilte Kühlvorrichtung (360, 365), wobei die geteilte Kühlvorrichtung (360, 365) in Fluidverbindung mit dem Leitkanal (350, 355) ist.

10. Einrichtung (300) nach Anspruch 9,wobei jeder Leitkanal (350, 355) mindestens einen Abschnitt umfasst, der ein starres Material, ein flexibles Material, ein gelenkiger Abschnitt, ein flexibler Abschnitt oder eine Kombination davon ist.

11. Einrichtung (300) nach Anspruch 9 oder Anspruch 10, wobei die geteilte Kühlvorrichtung (360, 365) betriebsfähig mit dem (der) einen oder den mehreren Systemen oder Komponenten gekoppelt ist.

12. Einrichtung (300) nach Anspruch 1 oder einem vorstehenden Einrichtungsanspruch, wobei das (die) eine oder die mehr Systeme oder Komponenten ein Hauptrotorgetriebe (114), ein Hilfsgetriebe (116a, 116b), eine oder mehr Komponenten, die vom Hilfsgetriebe (116a, 116b) angetrieben werden, ein Untersetzungsgetriebe (216a, 216b), ein Hydrauliksystem, ein Schmierungssystem oder ein Temperaturregelsystem umfassen.

13. Einrichtung (300) nach Anspruch 1 oder einem vorstehenden Einrichtungsanspruch, wobei die geteilte Kühlvorrichtung (305) betriebsfähig mit dem (der) einen oder den mehreren Systemen oder Komponenten gekoppelt ist.

14. Verfahren zum Kühlen eines (einer) oder mehr Systeme oder Komponenten, umfassend:

Bereitstellen einer geteilten Kühlvorrichtung (305) für das (die) eine oder mehr Systeme oder Komponenten; und
Anordnen jeder einer Vielzahl von primären Kühlleitbahnen in Fluidverbindung mit der geteilten Kühlvorrichtung (305) durch:

Anordnen eines Überleitschachts (320, 325) in Fluidverbindung mit der geteilten Kühlvorrichtung (305);
Anordnen eines Lüfters (340, 345) in Fluidverbindung mit der Übertragungsleitung (320, 325); und **gekennzeichnet durch**
Anordnen eines geteilten Verbinders (310) in Fluidverbindung mit der geteilten Kühlvorrichtung (305), wobei der geteilte Verbinder (310) eine Vielzahl von Kanälen (316, 317) umfasst; und
Anordnen für jede der primären Kühlleitbahnen des Überleitschachts (320, 325), um betriebsfähig konfigurierbar zu sein, in Fluidverbindung mit einem der Kanäle (316, 317) zu sein.

15. Verfahren nach Anspruch 14, weiter umfassend An-

ordnen eines Trennstegs (315) innerhalb des geteilten Verbinders (310), wobei der Trennsteg (315) jeden der Kanäle (316, 317) der Vielzahl von Kanälen (316, 317) von allen der anderen Kanäle (316, 317) trennt.

16. Verfahren nach Anspruch 15, wobei der Trennsteg (315) gelenkig oder angetrieben ist, um sich zu bewegen, um im Wesentlichen die gesamte geteilte Kühlvorrichtung (305) in Fluidverbindung mit einer primären Kühlleitbahn der Vielzahl von primären Kühlleitbahnen zu platzieren.

17. Verfahren nach Anspruch 15 oder nach Anspruch 16, wobei die geteilte Kühlvorrichtung (305) eine Vielzahl von Kernen umfasst, wobei jeder Kern konfiguriert ist, eines (eine) des (der) einen oder mehr Systeme oder Komponenten zu kühlen und weiter Anordnen jedes Kerns in einer Ausrichtung zum Trennsteg (315) oder zu den Überleitschachten (320, 325) umfasst, sodass jeder Kern in Fluidverbindung mit mindestens einer der Vielzahl von primären Kühlleitbahnen ist.

18. Verfahren nach Anspruch 14 oder nach einem der Ansprüche 15 bis 17, wobei der geteilte Verbinder (310) mindestens einen Abschnitt umfasst, der ein starres Material, ein flexibles Material, ein gelenkiger Abschnitt, ein flexibler Abschnitt oder eine Kombination davon ist.

19. Verfahren nach Anspruch 14 oder nach einem vorstehenden Verfahrensanspruch, weiter umfassend Anordnen eines Überleitverbinders (330, 335) für jede von einer oder mehr primären Kühlleitbahnen durch:

Anordnen des Überleitverbinders (330, 335) in Fluidverbindung mit dem Überleitschacht (320, 325) der primären Kühlleitbahn; und
Anordnen des Überleitverbinders (330, 335) in Fluidverbindung mit dem Lüfter (340, 345) der primären Kühlleitbahn.

20. Verfahren nach Anspruch 19, wobei der Überleitverbinder (330, 335) mindestens einen Abschnitt umfasst, der ein starres Material, ein flexibles Material, ein gelenkiger Abschnitt, ein flexibler Abschnitt oder eine Kombination davon ist.

21. Verfahren nach Anspruch 14 oder nach einem vorstehenden Verfahrensanspruch, wobei jeder der Überleitschachte (320, 325) mindestens einen Abschnitt umfasst, der ein starres Material, ein flexibles Material, ein gelenkiger Abschnitt, ein flexibler Abschnitt oder eine Kombination davon ist.

22. Verfahren nach Anspruch 14 oder nach einem vorstehenden Verfahrensanspruch, weiter umfassend Anordnen jeder von einer oder mehr sekundären Kühlleitbahnen in Fluidverbindung mit einer der primären Kühlleitbahnen durch:

Anordnen eines Leitkanals (350, 355) in Fluidverbindung mit dem Überleitschacht (320, 325) der einen der primären Kühlleitbahnen; und
Anordnen einer verteilten Kühlvorrichtung (360, 365) in Fluidverbindung mit dem Leitkanal (350, 355).

23. Verfahren nach Anspruch 22, wobei der Leitkanal (350, 355) mindestens einen Abschnitt umfasst, der ein starres Material, ein flexibles Material, ein gelenkiger Abschnitt, ein flexibler Abschnitt oder eine Kombination davon ist.

24. Verfahren nach Anspruch 22 oder nach Anspruch 23, weiter umfassend betriebsfähiges Koppeln der verteilten Kühlvorrichtung (360, 365) von jeder der einen oder mehr sekundären Kühlleitbahnen mit einem (einer) oder mehr Systemen oder Komponenten.

25. Verfahren nach Anspruch 14 oder nach einem vorstehenden Verfahrensanspruch, wobei das (die) eine oder mehr Systeme oder Komponenten ein Hauptrotorgetriebe (114), ein Hilfsgetriebe (116a, 116b), eine oder mehr Komponenten, die vom Hilfsgetriebe (116a, 116b) angetrieben werden, ein Untersetzungsgetriebe (216a, 216b), ein Hydrauliksystem, ein Schmierungssystem oder ein Temperaturregelsystem umfassen.

26. Verfahren nach Anspruch 14 oder nach einem vorstehenden Verfahrensanspruch, weiter umfassend betriebsfähiges Koppeln der geteilten Kühlvorrichtung (305) mit dem (der) einen oder mehr Systemen oder Komponenten.

27. Rotorflugzeug (100), umfassend:

einen Rumpf (102);
einen oder mehrere Motoren (120a, 120b), die mit dem Rumpf (102) gekoppelt sind;
eine geteilte Kühlvorrichtung für ein(e) oder mehr Systeme oder Komponenten, wobei die geteilte Kühlvorrichtung (305) mit dem (der) einen oder mehr Systemen oder Komponenten gekoppelt ist;
eine Vielzahl von primären Kühlleitbahnen, wobei jede der primären Kühlleitbahnen umfasst:

einen Überleitschacht, wobei der Überleitschacht in Fluidverbindung mit der geteilten Kühlvorrichtung ist; und
einen Lüfter, wobei der Lüfter in Fluidver-

bindung mit dem Überleitschacht ist; und **gekennzeichnet durch**

einen geteilten Verbinder (310) in Fluidverbindung mit der geteilten Kühlvorrichtung (305);

wobei der geteilte Verbinder (310) eine Vielzahl von Kanälen (316, 317) umfasst; und

wobei jede der primären Kühlleitbahnen betriebsfähig konfiguriert ist, in Fluidverbindung mit einem der Kanäle (316, 317) zu sein.

Revendications

1. Appareil de refroidissement (300), comprenant :

   un dispositif de refroidissement partagé (305) pour un ou plusieurs systèmes ou composants ;

   une pluralité de trajets de refroidissement primaires, dans lequel chacun des de refroidissement primaires comprend :

   un conduit de transition (320, 325), dans lequel le conduit de transition (320, 325) est en communication fluidique avec le dispositif de refroidissement partagé (305) ; et

   un ventilateur (340, 345), dans lequel le ventilateur (340, 345) est en communication fluidique avec le conduit de transition (320, 325) ; et **caractérisé par**

   un connecteur partagé (310) en communication fluidique avec le dispositif de refroidissement partagé (305) ;

   dans lequel le connecteur partagé (310) comprend une pluralité de canaux (316, 317) ; et

   dans lequel chacun des trajets de refroidissement primaires est configuré de manière opérationnelle pour être en communication fluidique avec l'un des canaux (316, 317).

2. Appareil (300) selon la revendication 1, comprenant en outre une cloison (315) à l'intérieur du connecteur partagé (310), dans lequel la cloison (315) sépare chacun des canaux (316, 317) de la pluralité de canaux (316, 317) de tous les autres canaux (316, 317).

3. Appareil (300) selon la revendication 2, dans lequel la cloison (315) est articulée ou actionnée pour se déplacer afin de placer sensiblement tout le dispositif de refroidissement partagé (305) en communication fluidique avec un trajet de refroidissement primaire de la pluralité de trajets de refroidissement primaires.

4. Appareil (300) selon la revendication 2 ou la revendication 3, dans lequel le dispositif de refroidissement partagé (305) comprend une pluralité de noyaux, dans lequel chaque noyau est configuré pour refroidir l'un des un ou plusieurs systèmes ou composants, et dans lequel chaque noyau est orienté vers la cloison (315) ou les conduits de transition (320, 325) de telle sorte que chaque noyau est en communication fluidique avec au moins l'un de la pluralité de trajets de refroidissement primaires.

5. Appareil (300) selon la revendication 1 ou l'une quelconque des revendications 2 à 4, dans lequel le connecteur partagé (310) comprend au moins une partie qui est un matériau rigide, un matériau flexible, une partie articulée, une partie flexible, ou une combinaison de ceux-ci.

6. Appareil (300) selon la revendication 1 ou une quelconque revendication d'appareil précédente, dans lequel chacun des un ou plusieurs trajets de refroidissement primaires comprend en outre un connecteur de transition (330, 335), dans lequel :

   le connecteur de transition (330, 335) est en communication fluidique avec le conduit de transition (320, 325) du trajet de refroidissement primaire ; et

   le connecteur de transition (330, 335) est en communication fluidique avec le ventilateur (340, 345) du trajet de refroidissement primaire.

7. Appareil (300) selon la revendication 6, dans lequel le connecteur de transition (330, 335) comprend au moins une partie qui est un matériau rigide, un matériau flexible, une partie articulée, une partie flexible, ou une combinaison de ceux-ci.

8. Appareil (300) selon la revendication 1 ou une quelconque revendication d'appareil précédente, dans lequel chacun des conduits de transition (320, 325) comprend au moins une partie qui est un matériau rigide, un matériau flexible, une partie articulée, une partie flexible, ou une combinaison de ceux-ci.

9. Appareil (300) selon la revendication 1 ou une quelconque revendication d'appareil précédente, comprenant en outre un ou plusieurs trajets de refroidissement secondaires, dans lequel chacun des un ou plusieurs trajets de refroidissement secondaires comprend :

   un conduit (350, 355), dans lequel le conduit (350, 355) est en communication fluidique avec le conduit de transition (320, 325) de l'un des trajets de refroidissement primaires ; et

   un dispositif de refroidissement distribué (360, 365), dans lequel le dispositif de refroidissement distribué (360, 365) est en communication fluidique avec le conduit (350, 355).

10. Appareil (300) selon la revendication 9, dans lequel chaque conduit (350, 355) comprend au moins une partie qui est un matériau rigide, un matériau flexible, une partie articulée, une partie flexible, ou une combinaison de ceux-ci.

11. Appareil (300) selon la revendication 9 ou la revendication 10, dans lequel le dispositif de refroidissement distribué (360, 365) est couplé de manière opérationnelle aux un ou plusieurs systèmes ou composants.

12. Appareil (300) selon la revendication 1 ou une quelconque revendication d'appareil précédente, dans lequel les un ou plusieurs systèmes ou composants comprennent une boîte de transmission de rotor principal (114), une boîte de transmission d'accessoires (116a, 116b), un ou plusieurs composants entraînés par le boîte de transmission d'accessoires (116a, 116b), une boîte de transmission de réducteur (216a, 216b), un système hydraulique, un système de lubrification, ou un système de commande de température.

13. Appareil (300) selon la revendication 1 ou une quelconque revendication d'appareil précédente, dans lequel le dispositif de refroidissement partagé (305) est couplé de manière opérationnelle aux un ou plusieurs systèmes ou composants.

14. Procédé de refroidissement d'un ou plusieurs systèmes ou composants, comprenant les étapes consistant à :

fournir un dispositif de refroidissement partagé (305) pour les un ou plusieurs systèmes ou composants ; et
disposer chacun d'une pluralité de trajets de refroidissement primaires en communication fluidique avec le dispositif de refroidissement partagé (305) en :

disposant un conduit de transition (320, 325) en communication fluidique avec le dispositif de refroidissement partagé (305) ;
disposer un ventilateur (340, 345) en communication fluidique avec le conduit de transition (320, 325) ; et **caractérisé par** les étapes consistant à
disposer un connecteur partagé (310) en communication fluidique avec le dispositif de refroidissement partagé (305), dans lequel le connecteur partagé (310) comprend une pluralité de canaux (316, 317) ; et
disposer pour chacun des trajets de refroidissement primaires le conduit de transition (320, 325) pouvant être configuré de manière opérationnelle pour être en communication fluidique avec l'un des canaux (316, 317).

15. Procédé selon la revendication 14, comprenant en outre la disposition d'une cloison (315) à l'intérieur du connecteur partagé (310), dans lequel la cloison (315) sépare chacun des canaux (316, 317) de la pluralité de canaux (316, 317) de tous les autres canaux (316, 317).

16. Procédé selon la revendication 15, dans lequel la cloison (315) est articulée ou actionnée pour se déplacer afin de placer sensiblement tout le dispositif de refroidissement partagé (305) en communication fluidique avec un trajet de refroidissement primaire de la pluralité de trajets de refroidissement primaires.

17. Procédé selon la revendication 15 ou la revendication 16, dans lequel le dispositif de refroidissement partagé (305) comprend une pluralité de noyaux, dans lequel chaque noyau est configuré pour refroidir l'un des un ou plusieurs systèmes ou composants, et comprenant en outre l'étape consistant à disposer chaque noyau dans une orientation vers la cloison (315) ou les conduits de transition (320, 325) de telle sorte que chaque noyau est en communication fluidique avec au moins l'un de la pluralité de trajets de refroidissement primaires.

18. Procédé selon la revendication 14 ou l'une quelconque des revendications 15 à 17, dans lequel le connecteur partagé (310) comprend au moins une partie qui est un matériau rigide, un matériau flexible, une partie articulée, une partie flexible, ou une combinaison de ceux-ci.

19. Procédé selon la revendication 14 ou une quelconque revendication de procédé précédente, comprenant en outre l'étape consistant à disposer un connecteur de transition (330, 335) pour chacun des un ou plusieurs trajets de refroidissement primaires en :

disposer le connecteur de transition (330, 335) en communication fluidique avec le conduit de transition (320, 325) du trajet de refroidissement primaire ; et
disposer le connecteur de transition (330, 335) en communication fluidique avec le ventilateur (340, 345) du trajet de refroidissement primaire.

20. Procédé selon la revendication 19, dans lequel le connecteur de transition (330, 335) comprend au moins une partie qui est un matériau rigide, un matériau flexible, une partie articulée, une partie flexible, ou une combinaison de ceux-ci.

21. Procédé selon la revendication 14 ou une quelconque revendication de procédé précédente, dans lequel chacun des conduits de transition (320, 325) comprend au moins une partie qui est un matériau rigide, un matériau flexible, une partie articulée, une partie flexible, ou une combinaison de ceux-ci.

22. Procédé selon la revendication 14 ou une quelconque revendication de procédé précédente, comprenant en outre l'étape consistant à disposer chacun d'un ou plusieurs trajets de refroidissement secondaires en communication fluidique avec l'un des trajets de refroidissement primaires en :

disposant un conduit (350, 355) en communication fluidique avec le conduit de transition (320, 325) de l'un des trajets de refroidissement primaires ; et
disposant un dispositif de refroidissement distribué (360, 365) en communication fluidique avec le conduit (350, 355).

23. Procédé selon la revendication 22, dans lequel le conduit (350, 355) comprend au moins une partie qui est un matériau rigide, un matériau flexible, une partie articulée, une partie flexible, ou une combinaison de ceux-ci.

24. Procédé selon la revendication 22 ou la revendication 23, comprenant en outre le couplage fonctionnel du dispositif de refroidissement distribué (360, 365) de chacun des un ou plusieurs trajets de refroidissement secondaires avec un ou plusieurs systèmes ou composants.

25. Procédé selon la revendication 14 ou une quelconque revendication de procédé précédente, dans lequel les un ou plusieurs systèmes ou composants comprennent une boîte de transmission de rotor principal (114), une boîte de transmission d'accessoires (116a, 116b), un ou plusieurs composants entraînés par le boîte de transmission d'accessoires (116a, 116b), une boîte de transmission de réducteur (216a, 216b), un système hydraulique, un système de lubrification, ou un système de commande de température.

26. Procédé selon la revendication 14 ou une quelconque revendication de procédé précédente, comprenant en outre un couplage fonctionnel du dispositif de refroidissement partagé (305) avec les un ou plusieurs systèmes ou composants.

27. Giravion (100), comprenant :

un fuselage (102) ;
un ou plusieurs moteurs (120a, 120b) couplés au fuselage (102) ;
un dispositif de refroidissement partagé pour un ou plusieurs systèmes ou composants, dans lequel le dispositif de refroidissement partagé (305) est couplé au ou aux systèmes ou composants ;
une pluralité de voies de refroidissement primaires, chacune des voies de refroidissement primaires parcours comprend :

un conduit de transition, dans lequel le conduit de transition est en communication fluidique avec le dispositif de refroidissement partagé ; et
un ventilateur, dans lequel le ventilateur est en communication fluide avec la transition canal ; et **caractérisé par**
un connecteur partagé (310) en communication fluidique avec le dispositif de refroidissement partagé (305) ;
dans lequel le connecteur partagé (310) comprend une pluralité de canaux (316, 317) ; et
dans lequel chacune des voies de refroidissement primaires est configurée de manière opérationnelle pour être en communication fluidique avec l'un des canaux (316, 317).

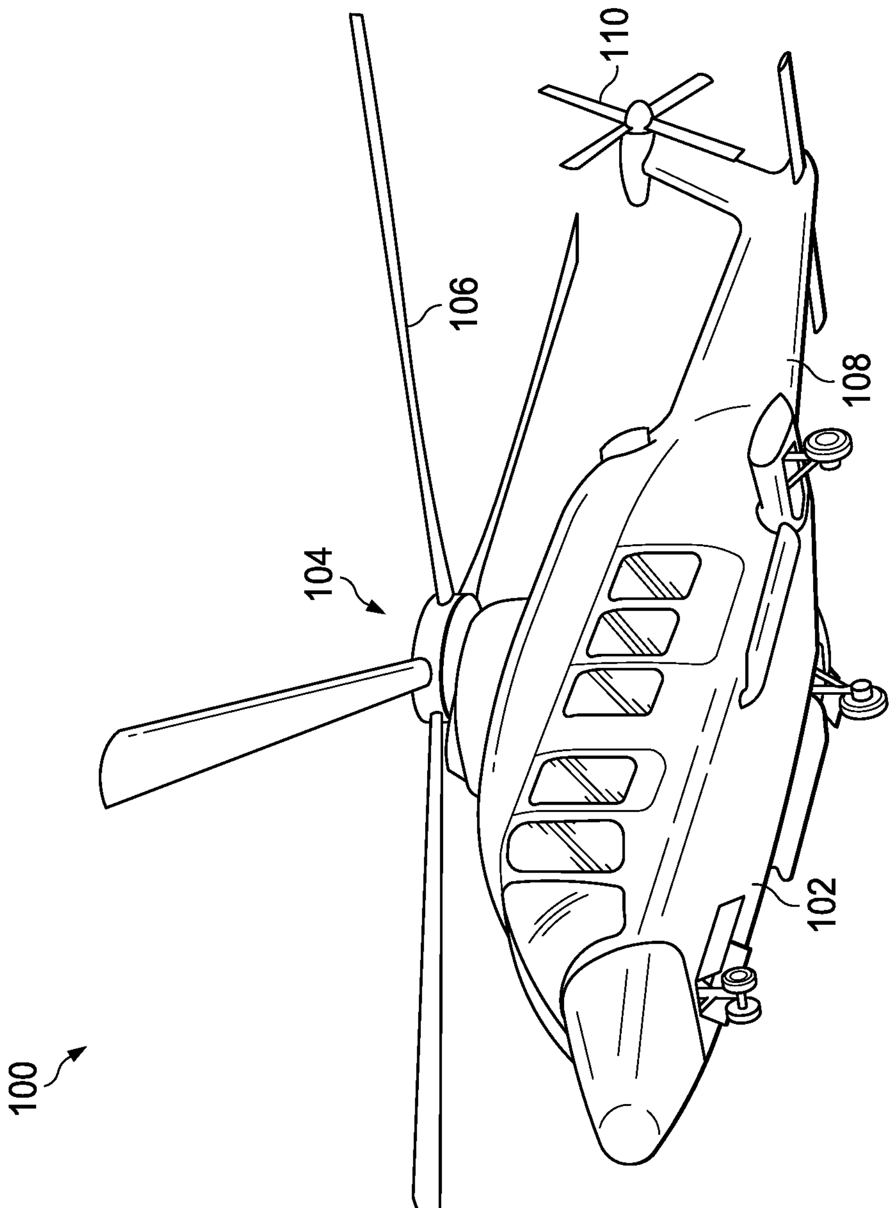

FIG. 1

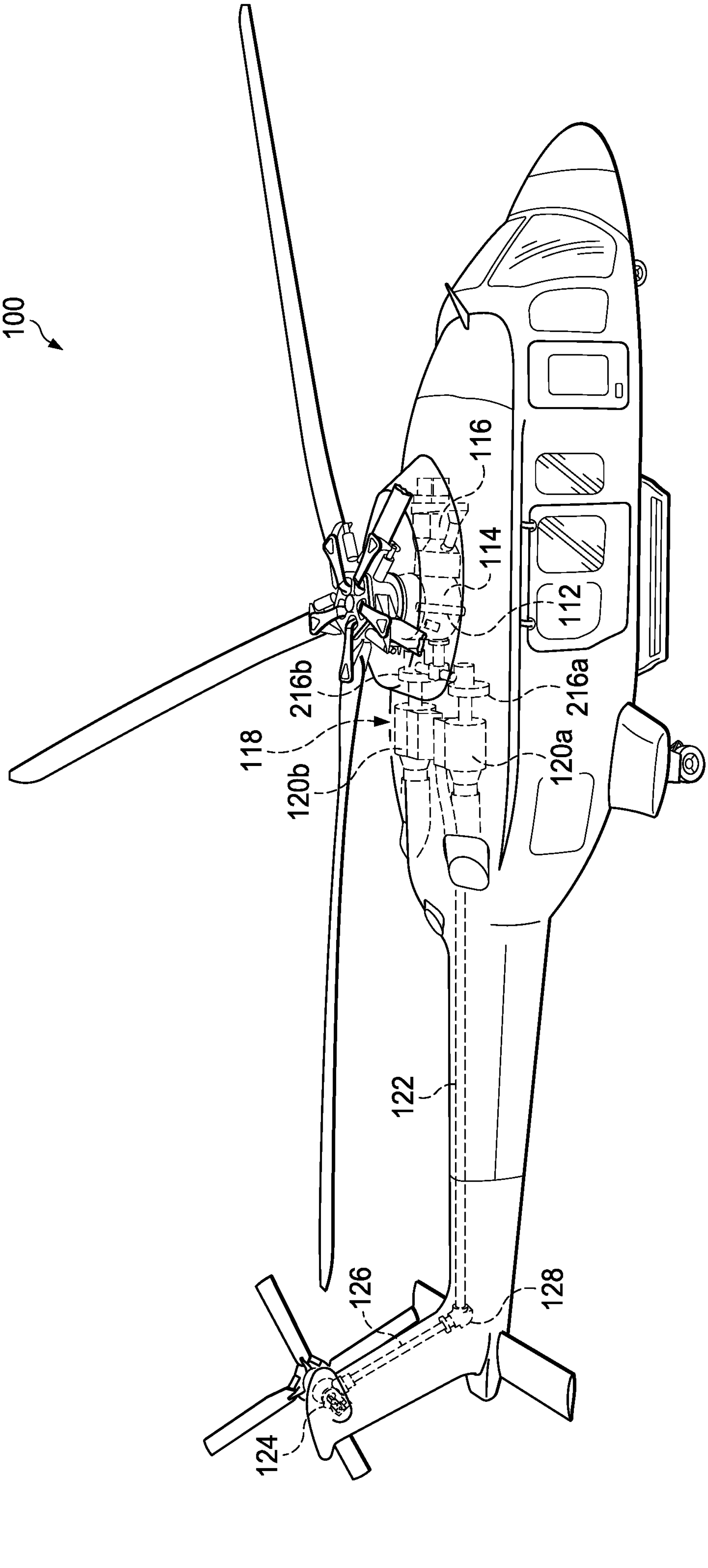

FIG. 2

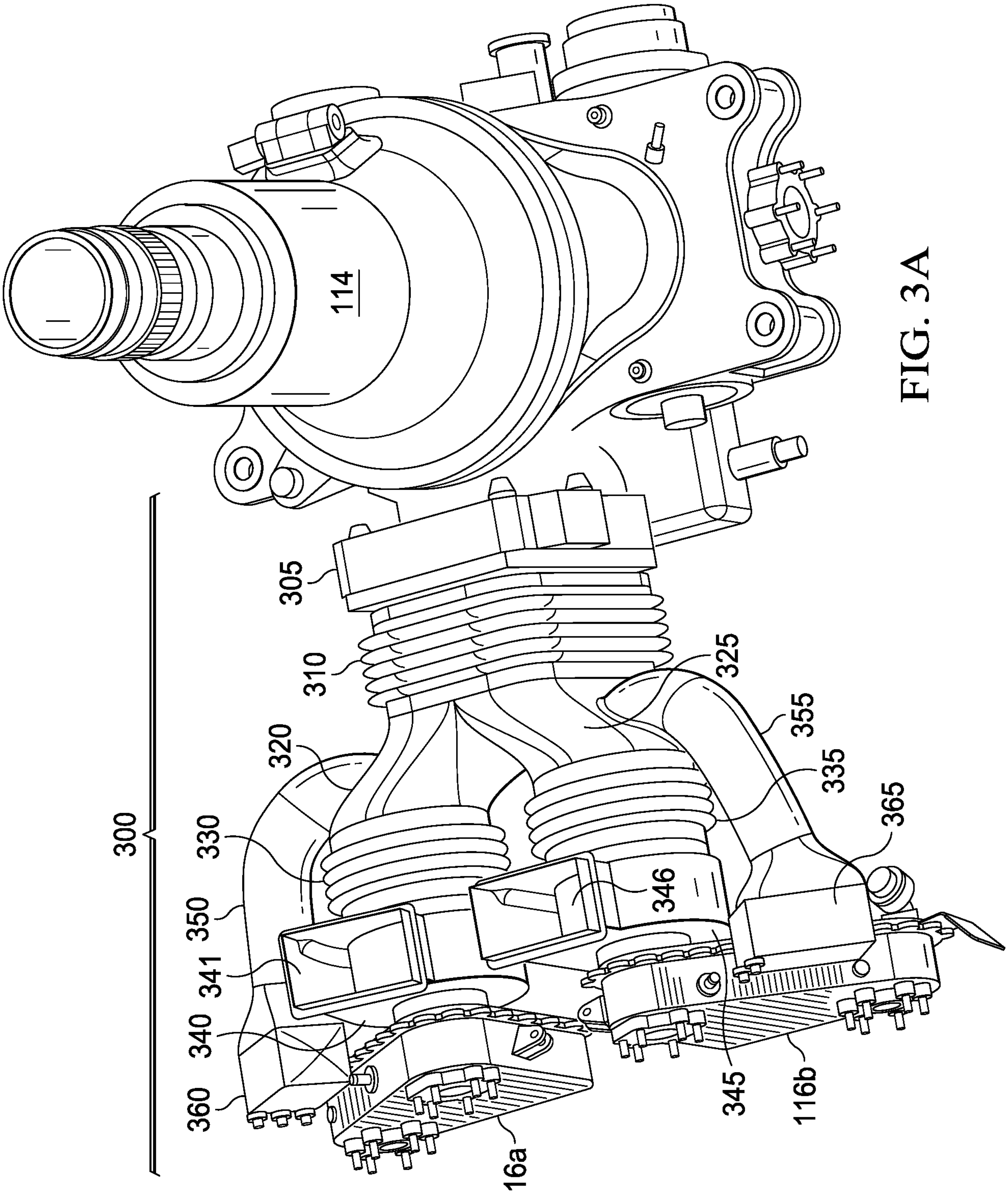
114
300
305
310
320
325
330
335
340
341
345
346
350
355
360
365
116a
116b

FIG. 3A

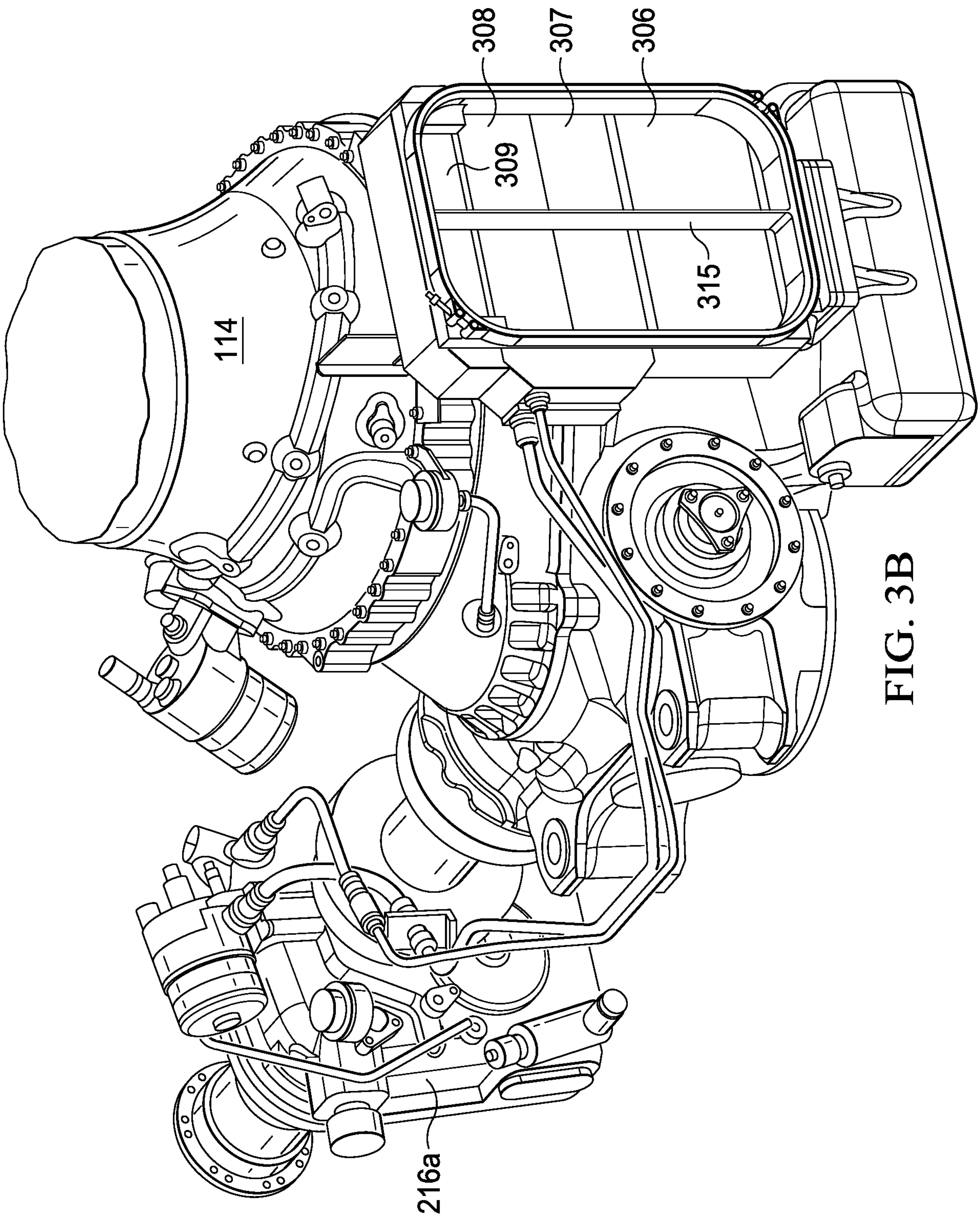

FIG. 3B

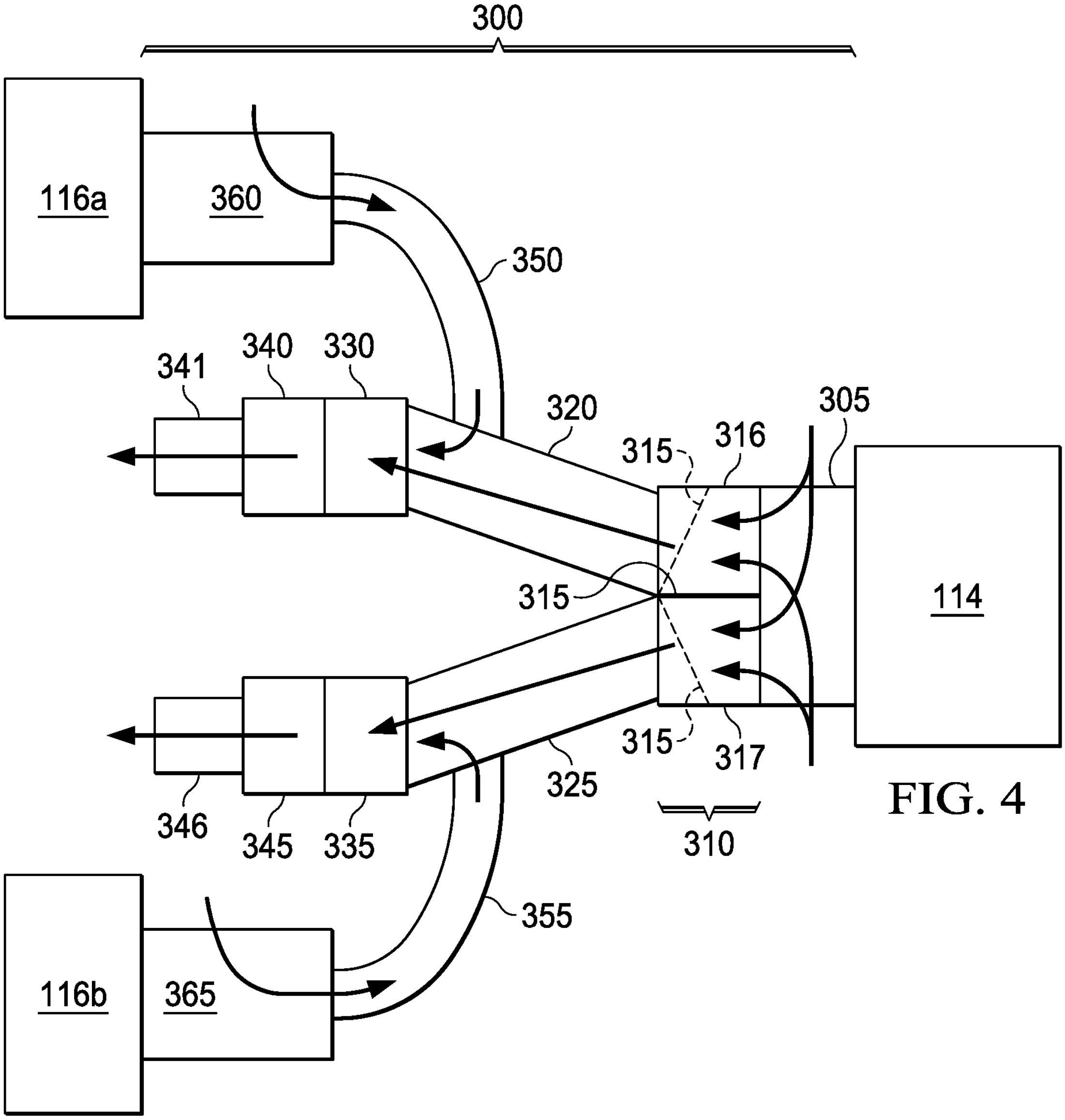
300
116a
360
350
341
340
330
320
315
316
305
114
315
315
317
325
346
345
335
310
355
116b
365

FIG. 4

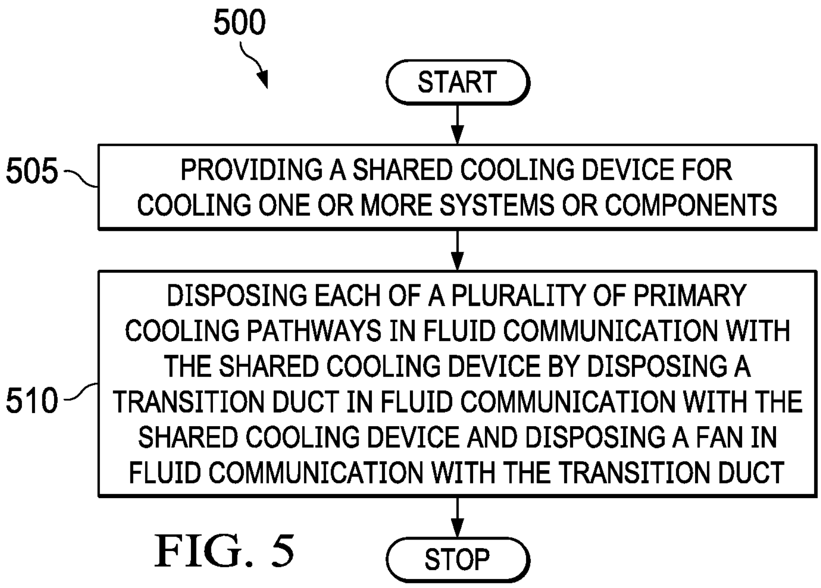
500
START
505
PROVIDING A SHARED COOLING DEVICE FOR COOLING ONE OR MORE SYSTEMS OR COMPONENTS
510
DISPOSING EACH OF A PLURALITY OF PRIMARY COOLING PATHWAYS IN FLUID COMMUNICATION WITH THE SHARED COOLING DEVICE BY DISPOSING A TRANSITION DUCT IN FLUID COMMUNICATION WITH THE SHARED COOLING DEVICE AND DISPOSING A FAN IN FLUID COMMUNICATION WITH THE TRANSITION DUCT
STOP

FIG. 5

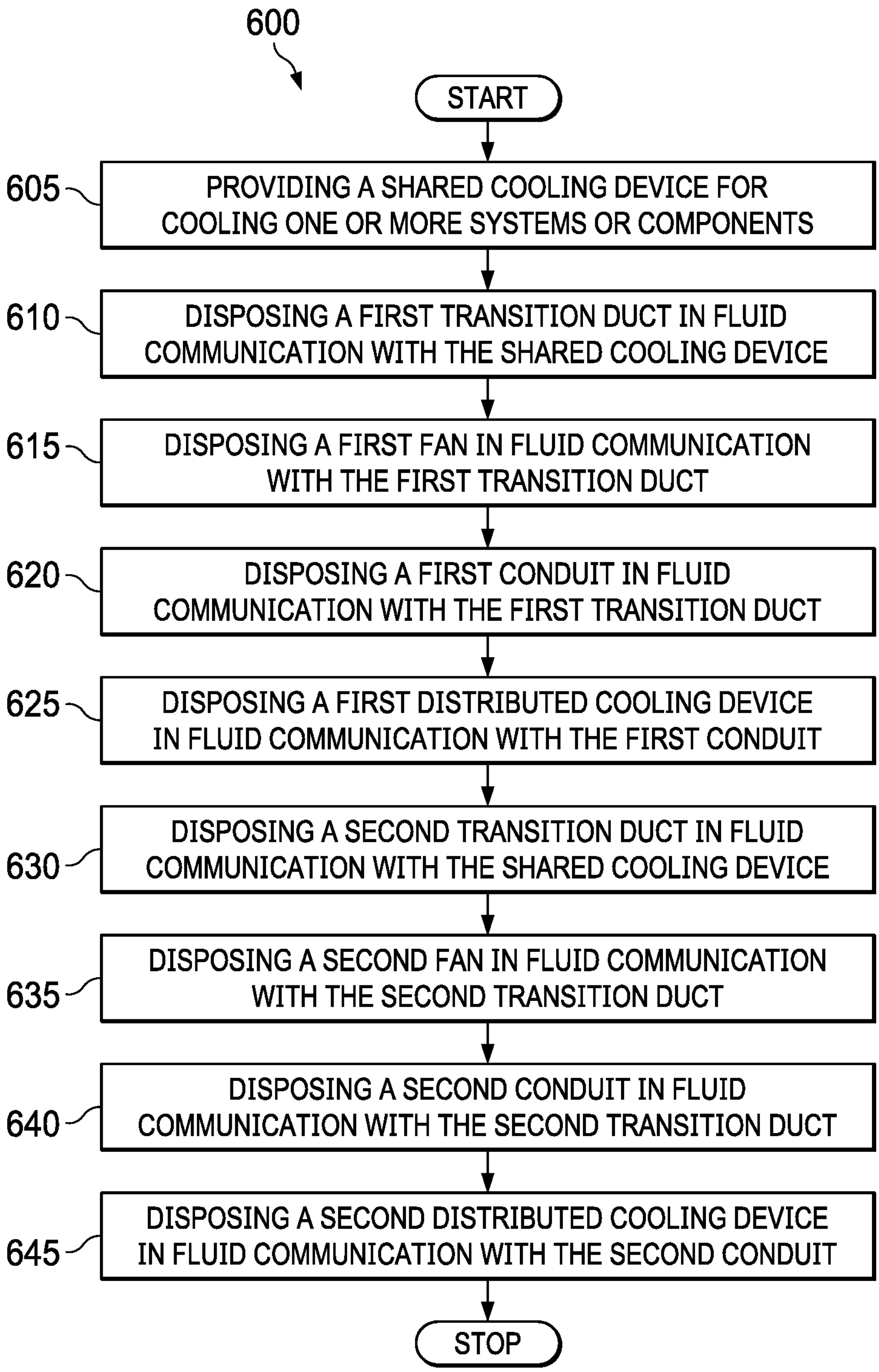
600
START
605
PROVIDING A SHARED COOLING DEVICE FOR COOLING ONE OR MORE SYSTEMS OR COMPONENTS
610
DISPOSING A FIRST TRANSITION DUCT IN FLUID COMMUNICATION WITH THE SHARED COOLING DEVICE
615
DISPOSING A FIRST FAN IN FLUID COMMUNICATION WITH THE FIRST TRANSITION DUCT
620
DISPOSING A FIRST CONDUIT IN FLUID COMMUNICATION WITH THE FIRST TRANSITION DUCT
625
DISPOSING A FIRST DISTRIBUTED COOLING DEVICE IN FLUID COMMUNICATION WITH THE FIRST CONDUIT
630
DISPOSING A SECOND TRANSITION DUCT IN FLUID COMMUNICATION WITH THE SHARED COOLING DEVICE
635
DISPOSING A SECOND FAN IN FLUID COMMUNICATION WITH THE SECOND TRANSITION DUCT
640
DISPOSING A SECOND CONDUIT IN FLUID COMMUNICATION WITH THE SECOND TRANSITION DUCT
645
DISPOSING A SECOND DISTRIBUTED COOLING DEVICE IN FLUID COMMUNICATION WITH THE SECOND CONDUIT
STOP

FIG. 6

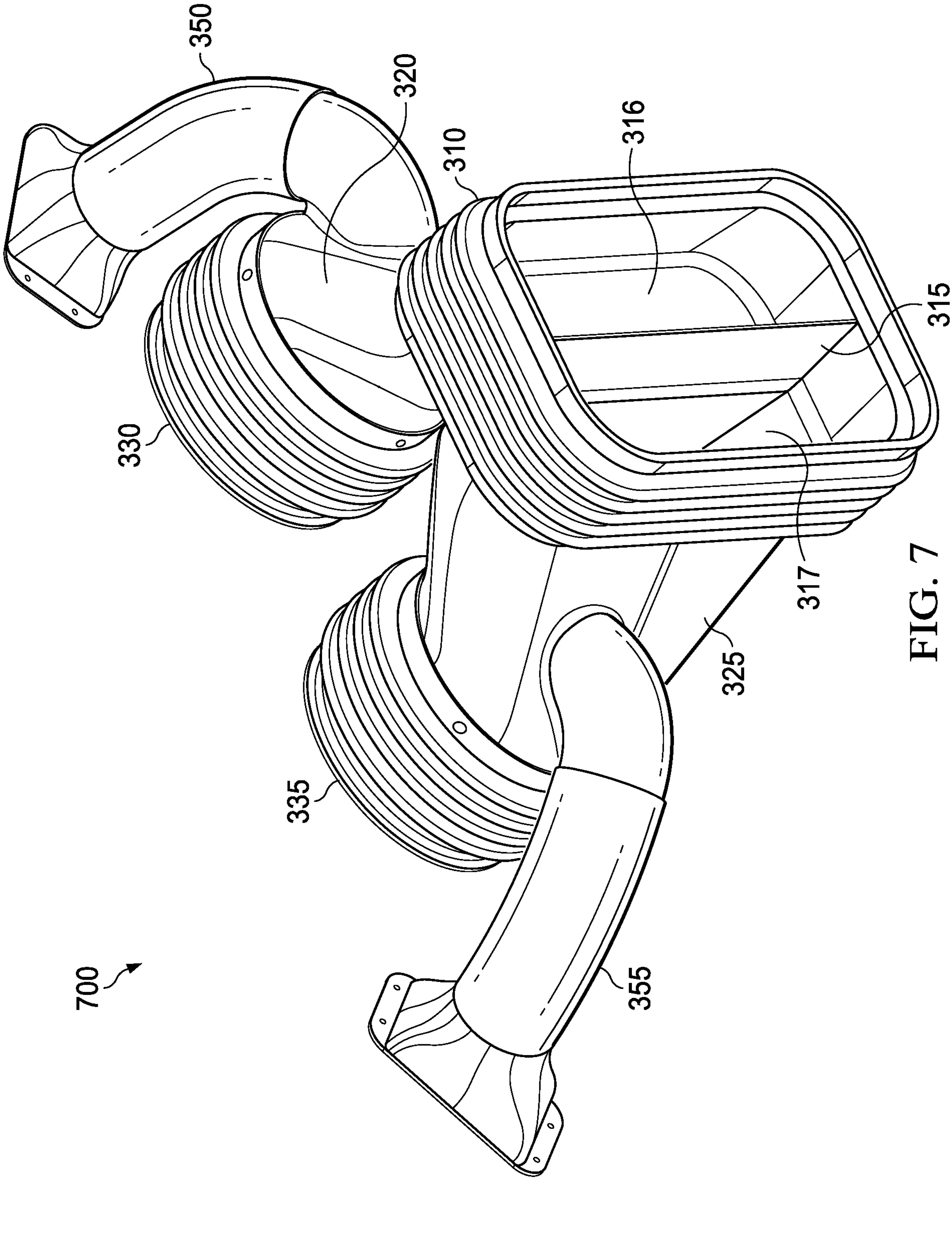

FIG. 7

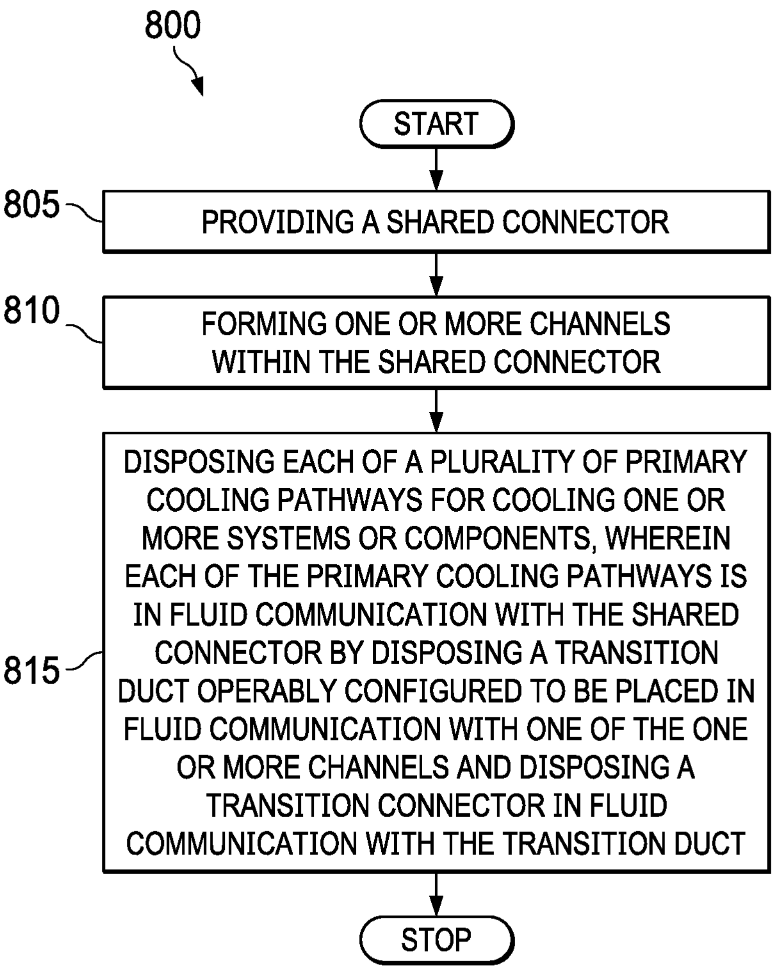
800
START
805
PROVIDING A SHARED CONNECTOR
810
FORMING ONE OR MORE CHANNELS WITHIN THE SHARED CONNECTOR
815
DISPOSING EACH OF A PLURALITY OF PRIMARY COOLING PATHWAYS FOR COOLING ONE OR MORE SYSTEMS OR COMPONENTS, WHEREIN EACH OF THE PRIMARY COOLING PATHWAYS IS IN FLUID COMMUNICATION WITH THE SHARED CONNECTOR BY DISPOSING A TRANSITION DUCT OPERABLY CONFIGURED TO BE PLACED IN FLUID COMMUNICATION WITH ONE OF THE ONE OR MORE CHANNELS AND DISPOSING A TRANSITION CONNECTOR IN FLUID COMMUNICATION WITH THE TRANSITION DUCT
STOP

FIG. 8

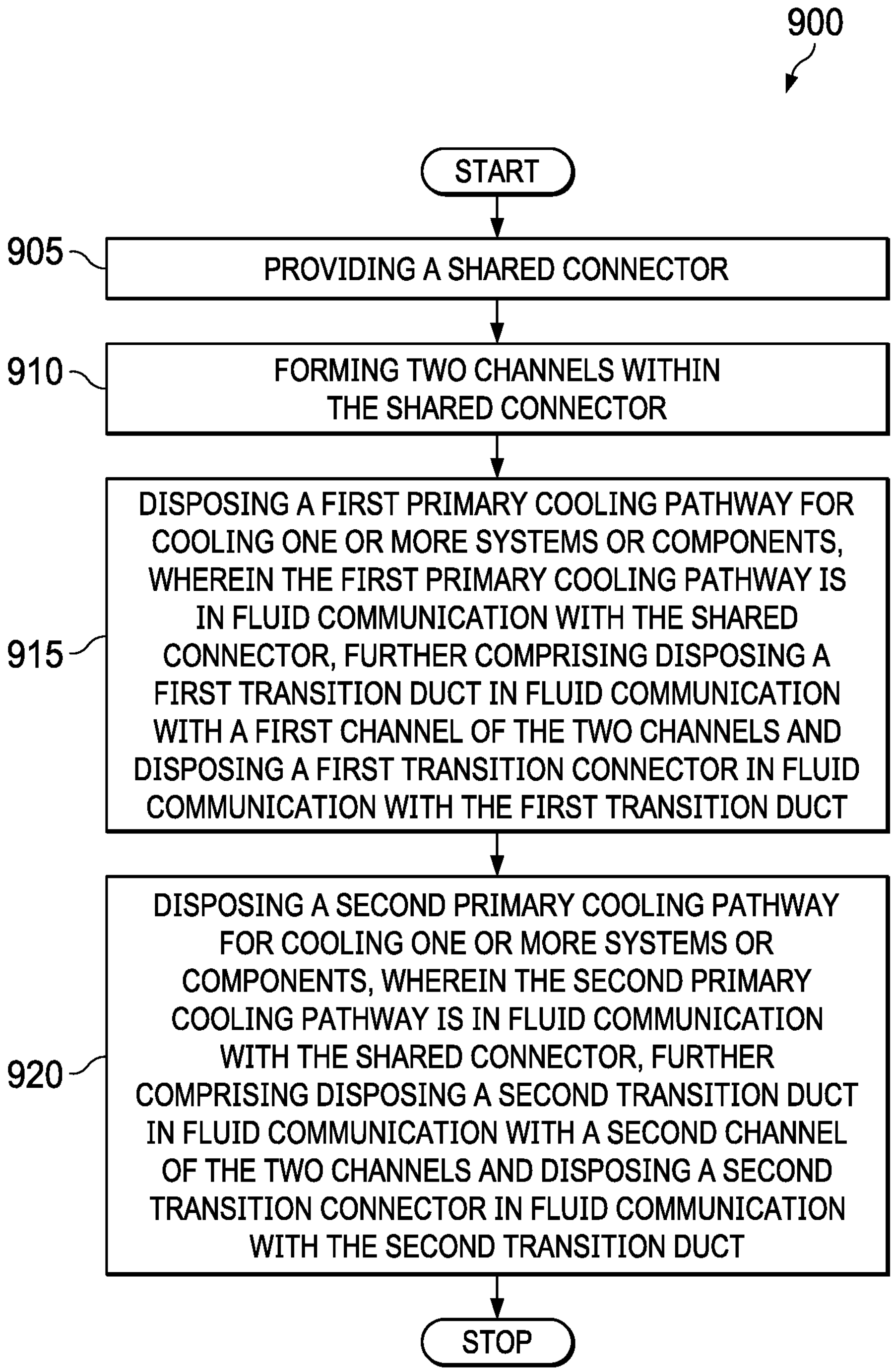
900
START
905
PROVIDING A SHARED CONNECTOR
910
FORMING TWO CHANNELS WITHIN THE SHARED CONNECTOR
915
DISPOSING A FIRST PRIMARY COOLING PATHWAY FOR COOLING ONE OR MORE SYSTEMS OR COMPONENTS, WHEREIN THE FIRST PRIMARY COOLING PATHWAY IS IN FLUID COMMUNICATION WITH THE SHARED CONNECTOR, FURTHER COMPRISING DISPOSING A FIRST TRANSITION DUCT IN FLUID COMMUNICATION WITH A FIRST CHANNEL OF THE TWO CHANNELS AND DISPOSING A FIRST TRANSITION CONNECTOR IN FLUID COMMUNICATION WITH THE FIRST TRANSITION DUCT
920
DISPOSING A SECOND PRIMARY COOLING PATHWAY FOR COOLING ONE OR MORE SYSTEMS OR COMPONENTS, WHEREIN THE SECOND PRIMARY COOLING PATHWAY IS IN FLUID COMMUNICATION WITH THE SHARED CONNECTOR, FURTHER COMPRISING DISPOSING A SECOND TRANSITION DUCT IN FLUID COMMUNICATION WITH A SECOND CHANNEL OF THE TWO CHANNELS AND DISPOSING A SECOND TRANSITION CONNECTOR IN FLUID COMMUNICATION WITH THE SECOND TRANSITION DUCT
STOP

FIG. 9

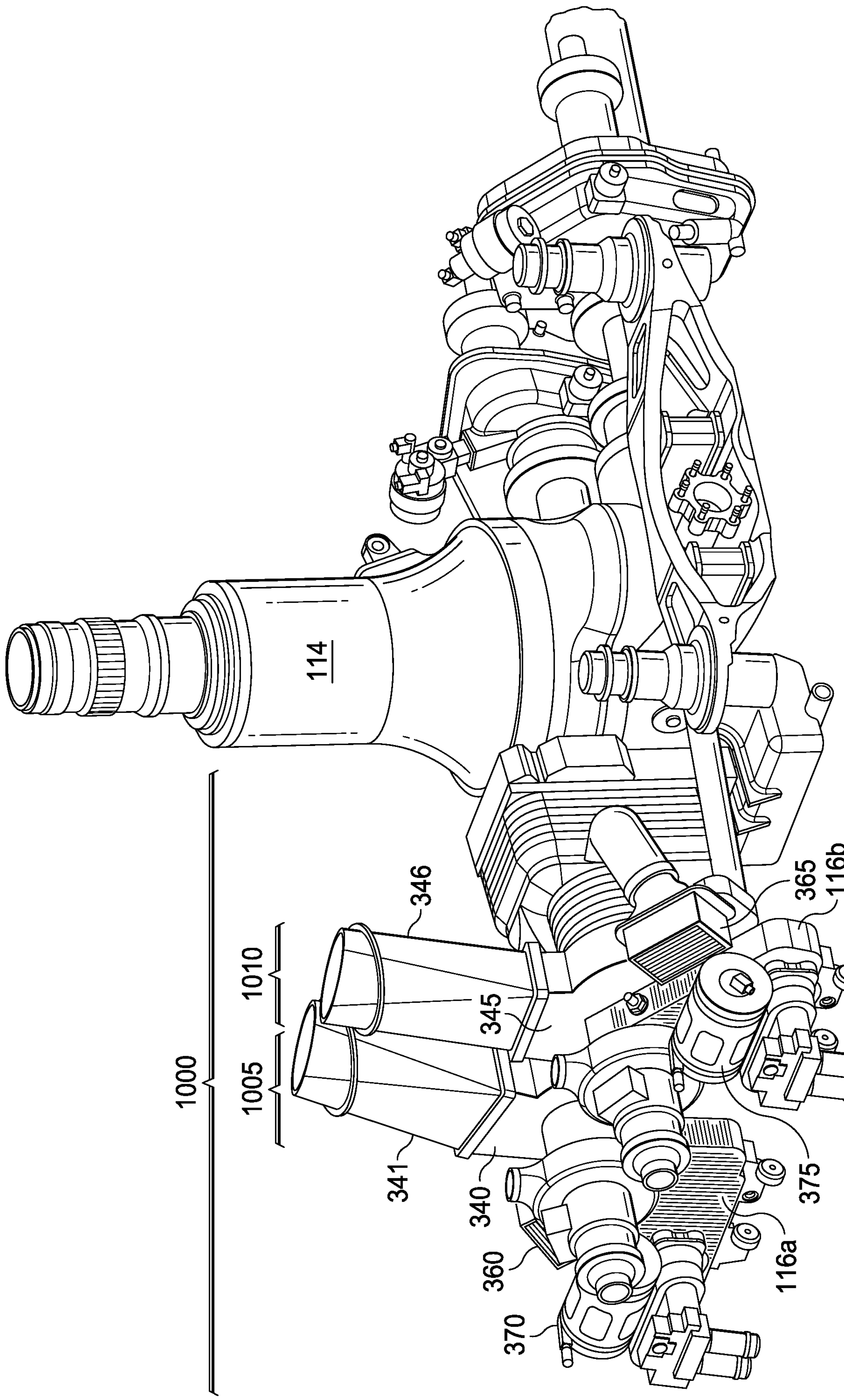

FIG. 10

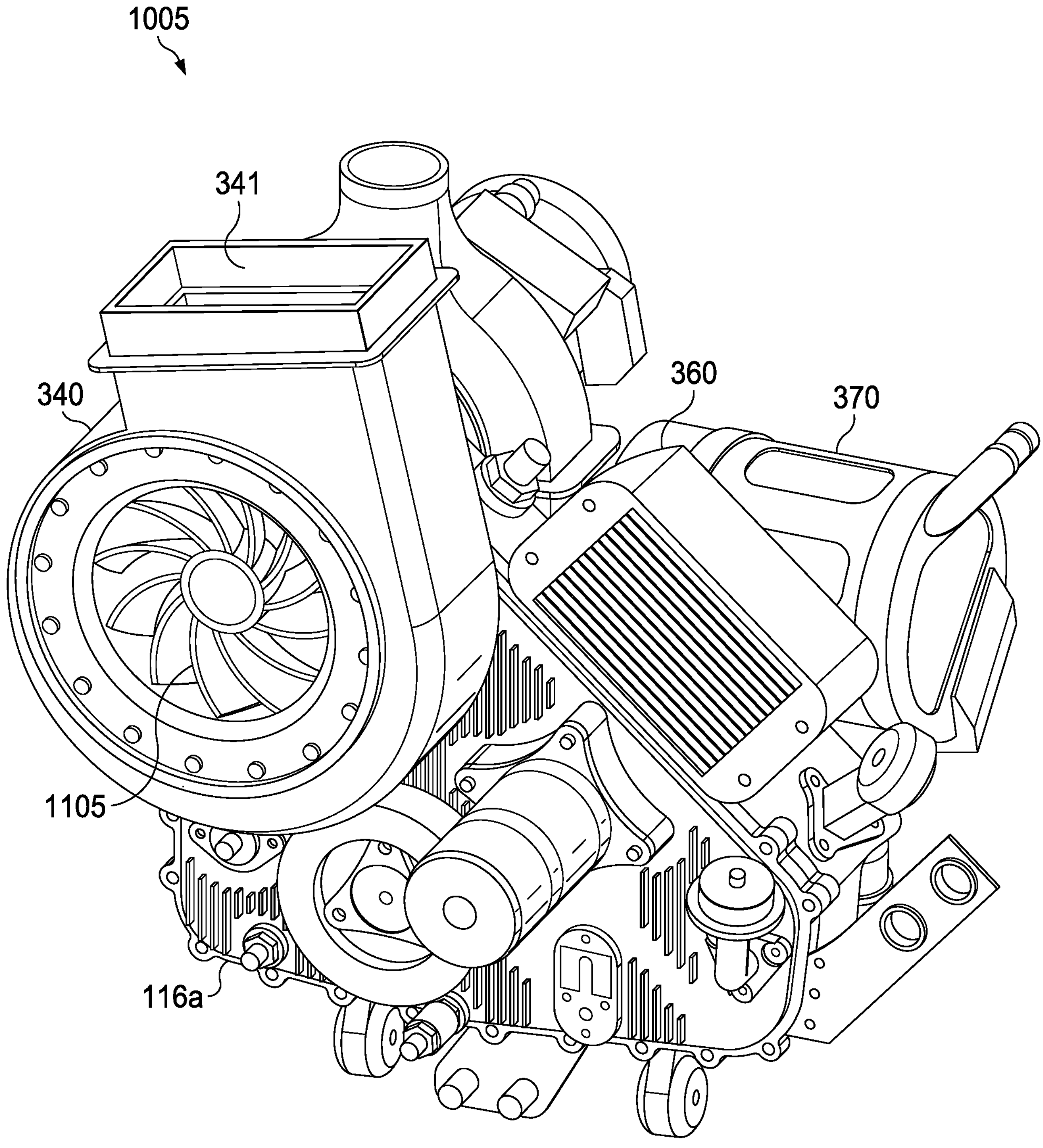

FIG. 11

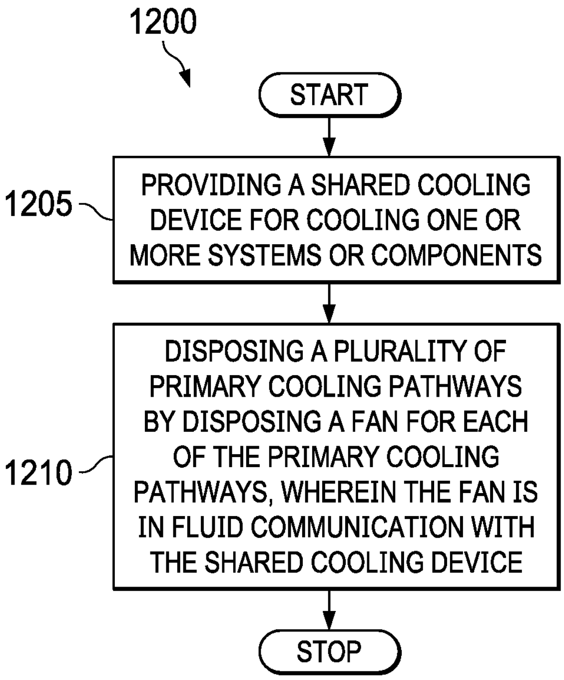

FIG. 12

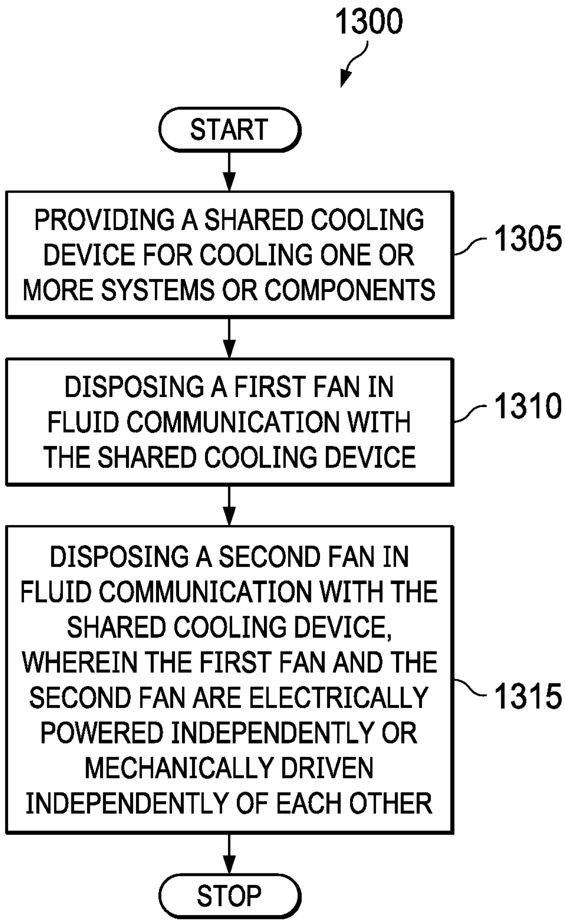

FIG. 13

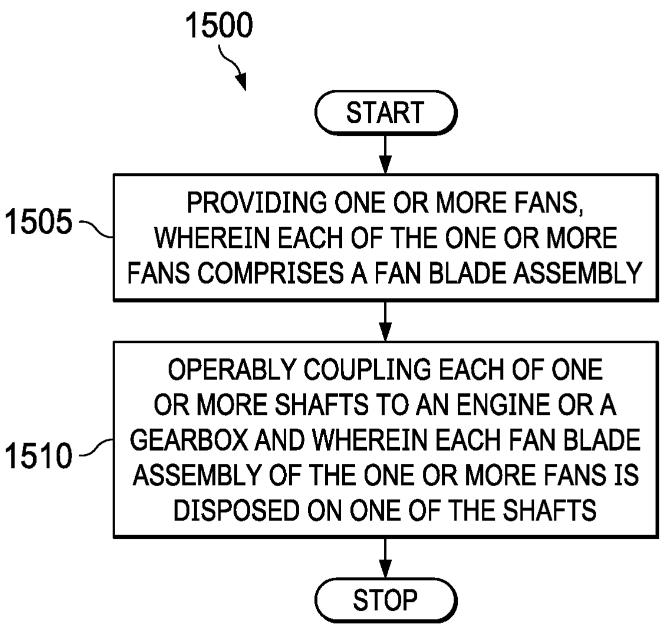

FIG. 15

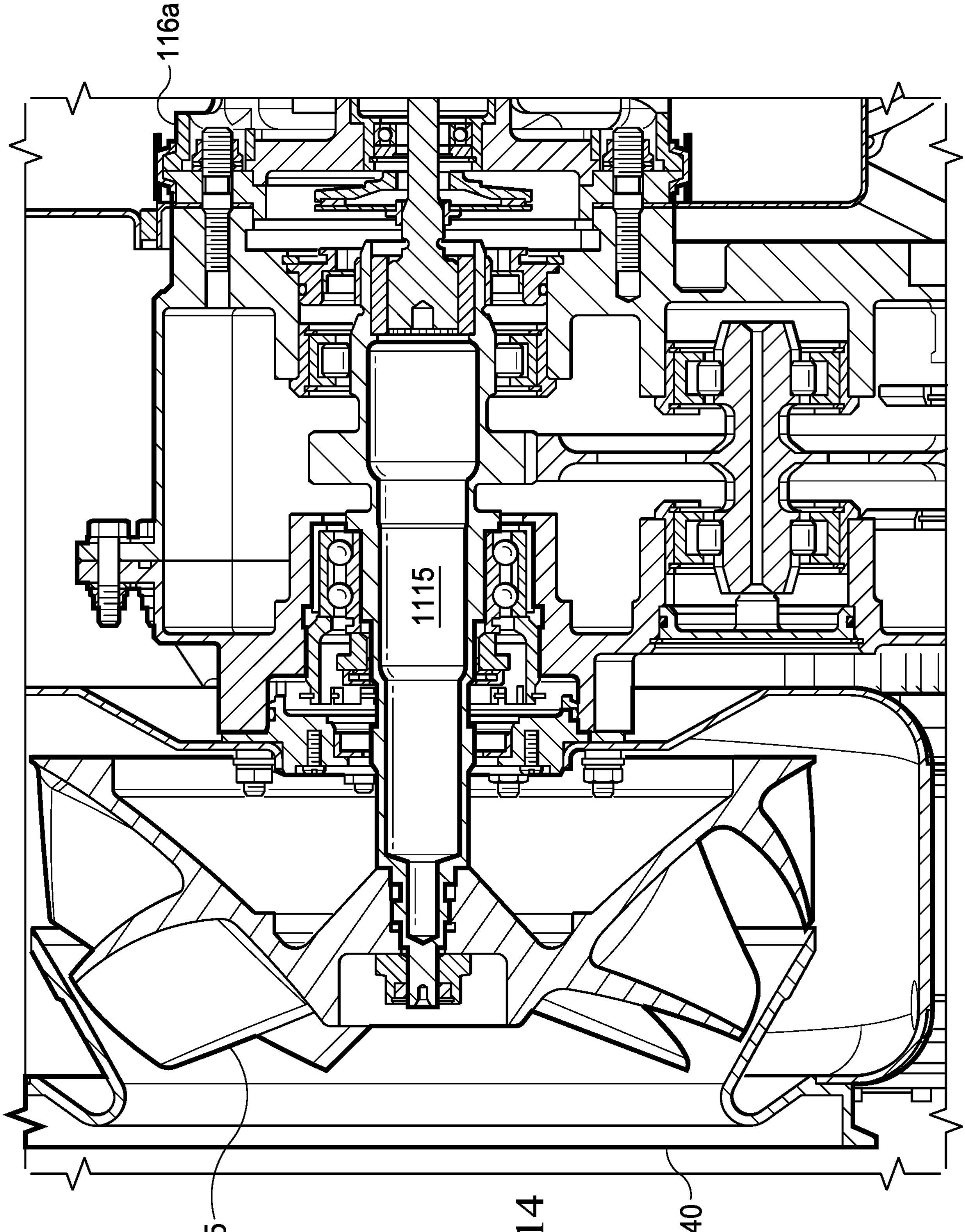

FIG. 14

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 4999994 A **[0006]**
- US 2006180703 A1 **[0007]**
- AU 2016100268 **[0008]**